NIV. OF
RONTO

Digitized by the Internet Archive
in 2008 with funding from
Microsoft Corporation

http://www.archive.org/details/marineengineerin11newyuoft

International Marine Engineering

VOLUME XI.

JANUARY TO DECEMBER, 1906.

8672 8
21 | 3 | 08

PUBLISHED BY
MARINE ENGINEERING, Incorporated
17 BATTERY PLACE, NEW YORK.
CHRISTOPHER STREET, FINSBURY SQUARE, LONDON, E.

INDEX.

NOTE.—Illustrated articles are marked with an (*) asterisk.

ARTICLES

	PAGE
Adriatic, White Star line	*368
Adventure, new English scout cruiser	*140
Agamemnon, battleship	*28
Alcohol as Fuel for Gas Engines. Diederichs	*264
A little story. Phule	150
American nautical school, need for. Van Vleck	*360
Amiral Aube, French armored cruiser	*128
Anita, 51-foot cruising launch	*106
Armored cruiser Black Prince. Perkins	*362
Ernest Renan, launching of	*249
Jules Ferry	*367
Maryland, steaming economy of. Dinger	*398
Natal, launching of	*63
St. Louis, trial of. Baldt	*294
Washington, trial trip of	*258
Armored cruisers, French. Peltier	*125
Asuncion, South American River Steamer	*281
Attentive, English scout cvruiser	*341
Barge, self-propelling ash, coal and water, No. 14	*142
Barges, steel. Donovan	*214
Battleship Agamemnon and Beardmore's new shipyard	*28
designs, comparison of new	*251
Dreadnought	*461
Idaho, launch of	*29
Indiana, propeller performance of. Dinger	*446
Louisiana, trial of. Bowen and Gregory	*165
Minnesota, dock trial of	*468
Nebraska, trial of	*442
New Hampshire, launching of	*319
New Jersey	*247
Rhode Island in commission	*141
Virginia in heavy weather	*475
Virginia, trial of. Bowen and Gregory	*83
Battleships, the new United States	142
Bellerophon, New type cargo liner, Taylor	*235
Bending moments of certain Lake steamers. Babcock	*41
Black Prince, English armored cruiser. Perkins	*362
Boiler shop of large shipyard	*232
Branwen, steam yacht	*317
British naval scouts	147
Brooke I, fast motor boat	*322
Bulkhead doors, official tests of electrically-operated	*137
Bureau Veritas, abstracts from. Taft. 198, 240, 284, 326, 372	410
Buxton, steamship	*436
Calculating the size of the cylinders for a multiple expansion engine. Elfers	24, 82
Canada. Canadian fishery cruiser. Whittemore	*152
Capstans and electric winches, English and American. Perkins	*178
Carmania, the new turbine liner	* 1
Cetus, large dredger for Natal	*365
City of Glasgow, the City Liner	*358
Clearance and receiver drop in the design of compound engines. Walker	*469
Coal depot, floating, in Portsmouth harbor	*406
Cold Storage on Board Ship. Walker	*259, 303, 346, 390, 427, 482
Comparison between turbines and reciprocating engines	*480
Compound engine design	*393
Compound engines, clearance and receiver drop in the design of. Walker	*469
Confessions of a Draftsman	432
Crane, floating scow derrick	*306
large shipbuilding	*270
Creole, twin screw turbine steamship	*379
Cruisers, British	147
Russian, in Manila Bay	*23
Cruising launch, 40-foot. Walton	*229
Curtis steam turbine, marine applications of. Curtis	19
Cylinders for multiple expansion engine. Elfers	24, 82
Dalmuir, suction gas producer vessel	*313
Designs for a fire boat, preliminary	*448
Destroyer, development of the. Harding	*96
Development of the marine steam turbine	*476
Dimensions of the steam turbine with special reference to marine work. Speakman	*50
Dongola, new P. & O. liner. Taylor	*46
Dreadnought, English battleship	*461
Dredger Cetus for Natal	*365
Vulcan. Guarini	*151
Dredges, gold. Coleman	*12
Dry dock in Greece	*315
at Southhampton, New Trafalgar	*392
Dry Docks, construction of floating. Donnelly	*449. 464
Electric plant on ferryboat Ludlow. Perkins	*146
Elizabeth Silsby, auxiliary fishing schooner	*108
Emil Capitaine, suction producer-gas yacht. Ramakers	*144
Empress of Britain, launch of	*16
Empress of Ireland, new Atlantic liner	*335
Engine, Calculating size of cylinders for multiple expansion. Elfers	24, 82
design, compound	*393
600-horsepower triple expansion	*314
Engineering and Shipbuilding features in Scotland	70
Engineering calculations, errors in naval. Tromp	320
Engineers in the Navy	322
Engines of English armored cruiser Black Prince	*362
steamship Buxton	*434
Ernest Renan, launching of French Armored Cruiser. Peltier	*249
Errors in naval engineering calculations	320
Evolution of the lifeboat. McLellan	*7
Experimental researches on the performance of screw propellers. Durand	*58
Ferryboat propulsion, some problems in. Stevens	*64
Ludlow, electric plant on. Perkins	*146
Fire Boat, a new motor-driven	*364
preliminary design	*448
Fireproof excursion steamer Jamestown. Wills	*419
Firing water tube boilers in large vessels. Dinger	*139
Fishery cruiser Canada. Whittemore	*152
Fishing boat, a new motor-driven	*110
Floating coal depot in Portsmouth Harbor. Perkins	*406
Floating dock, launch of small	*490
iron, at Tsingtau, China	*183
Floating Dry-Dock Construction. Donnelly	*449, 464
Floating scow derrick crane	*306
Florida, Italian Lloyd steamship. Attilio	*426
French and German navies, comparison of. Peltier	*217
Gambetta and Gloire, French armored cruisers. Peltier	*125
Gas Engines, use of kerosene oil in. Maxwell	*486
Gas engines, use of alcohol fuel. Diederichs	*264
Gasoline marine engines	70
Gas power for marine work. Tait	*311
German and French navies, comparison of. Peltier	*217
Gold dredges. Coleman	*12
Graving dock at Southampton, new Trafalgar	*392
Great Lakes Register, rules and regulations of, abstracts from. Taft	32, 74
Gunboat, a Central American	*93
Habana, steamer, for Cuba. Taylor	*490
Hamilton, lengthening of the steamer. Wills	*221
Hendrick Hudson	*191
High speed launches, problems in connection with	*89
Ice-breaker Montcalm	*20
Idaho, launching of	*29
Indiana, propeller performance of the. Dinger	*446
Jamestown, fireproof excursion steamer. Wills	*419
Japanese naval additions	140
Jules Ferry, French armored cruiser	*367
Kaiser, turbine-propelled steamer. Gradenwitz	*473
Kerosene oil in engines built for gasoline. Maxwell	*486
Lake steamers, bending moments of. Babcock	*41
La Provence, French Liner	*221, 342
Launch of armored cruiser Ernest Renan	*249
battleship Idaho	*29
battleship New Hampshire	*319
English cruiser Natal	*63
floating dock	*490
Hendrick Hudson	*191
Lusitania, Cunard Line	*291
small steamers	*401
Steamship Empress of Britain	*16
steam yacht Branwen	*317
turbine steamer Viper. M'Pherson	*321
Lifeboat, evolution of the. M'Lellan	*7
Lloyd's register for yachts, abstracts from. Taft	116
London County Council Passenger Steamers. Hogg	*233
Longitudinal bending moments of certain Lake steamers. Babcock	*41
Louisiana, contract trial performance of U. S. Battleship. Bowen and Gregory	*165
Ludlow, ferryboat, electric plant on. Perkins	*146
Lusitania, Cunard steamer	*233, 291
Machinery of steamer Trafford Hall	426
Marine machinery patented in 1788	*447
Marine railway work in Greece	*315
Maryland, steaming economy of U. S. S. Dinger	*398
Mauretania, new Cunarder. Taylor	*437
Maywood, new passenger steamer	*314
Merchant marine of France, proposed legislation for	11
Minnesota, dock trial of U. S. Battleship. Gregory	*468
Montcalm, Canadian ice breaker	*20
Motor boat, Anita, 51-foot cruising	*106
Brooke I	*322
Dalmuir. Producer gas	*313
Emil Capitaine, suction producer gas. Ramakers	*144
for fishing	*110
40-foot cruising. Walton	*229
half cabin ferry	*112
Slider	*71
Svip	*487
Veritas at full speed	*263
Motor boats. Durand. *21, 68, 93, 148, 180, 236, 277, 308, 366	403
Motor boats, problems in connection with high speed	*89
Motor fire boat, a new	*364
Motor torpedo boat	*491
Natal, new English cruiser	*63
Naval Vessels, Rules for Riveting. Taft	494
Nebraska, trial of the battleship	*442
New Hampshire, launch of U. S. Battleship	*319
New Jersey, Battleship	*247
Nieuw Amsterdam, Holland-America Liner	*207

PAGE

Orari, New Zealand meat-carrying steamer. Taylor *444
Patents, selected marine. *40, 80, 124, 164, 205, 246, 290, 333, 378, 418, 459..... 500
Pensacola hurricane *484
Philippine Nautical School, Van Vleck..... *360
Pipe thicknesses, Standard..... *152
Piping and Powering of ships. Smith..... *338
Pneumatic tools as applied to ship construction *354
Poderoso, steam tug for Argentina..... *128
Powering and Piping of ships. Smith..... *338
Problems in connection with high speed launches *89
Producer gas for marine work. Tait..... *311
vessel, Dalmuir *313
yacht, Emil Capitaine..... *144
Propeller performance of battleship Indiana. Dinger *446
Propellers, molding of. W. F. D..... *184
Propellers, researches on performance of. Durand *58
Propulsion, problems in ferryboat. Stevens. *64

Red tape and favoritism. Phule..... 150
Refrigeration on Shipboard. Walker. *259, 303, 346, 390, 427..... 482
Repair yard in New York harbor..... *403
Revenue Cutter No. 15, Shallow draft..... *129
Rhode Island, battleship in commission..... *141
Rules and Regulations of the Great Lakes Register. Taft 32, 74
Lloyd's Register for Yachts..... 116
United States Steamboat Inspection service 156
Bureau Veritas..198, 240, 284, 326, 372, 410
Rules for Riveting Naval Vessels..... 494
Russian cruisers in Manila Bay..... *23

Sailing vessels, speed of..... *111
St. Louis, trial performance of U. S. cruiser. Baldt *294
St. Peter, Lake steamer for Russia..... *281
San Francisco harbor. Green..... *350
School, nautical, Philippine. Van Vleck.... *360
Schooner, auxiliary fishing..... *108
Scout cruiser Adventure, English..... *146
Attentive, English *341
Shipbuilding in the United States in 1905... *26
survey of Scotch, in 1905. Taylor..... 104
Shipping, the world's..... 402
Shipyard, Beardmore's 28
boiler shop *232
management 432
repair, in New York harbor..... *403
Slider, motor boat..... *71
Society of Naval Architects and Marine Engineers, meeting of..... 481
South Shore, steel paddle wheel excursion steamer *307
Speed of sailing vessels..... *111
Stability calculations by planimeter. Anderson *174
Stairbuilding, Notes on. Taft..... *456
Steamer Asuncion, South American..... *281
Bellerophon, new type cargo..... *235
City of Glasgow..... *358
for Cuba. Taylor..... *490
for Russian Lake..... *281
Hamilton, lengthening of. Wills..... *224
Hendrick Hudson *191
Jamestown, fireproof excursion. Wills.. *419
Maywood, engine for..... *314
Orari, meat carrying. Taylor..... *444
passenger, for Oneida Lake..... *65
South Shore, steel paddle wheel excursion *307
Steamers, largest in the world..... *233
Steamers, side launching of small..... *491
Steamship Adriatic, White Star Liner..... *368
Buxton *436
Dongola, P. & O. Line. Taylor..... *46
Empress of Britain, Launch of..... *16
Empress of Ireland. Canadian Pacific Line *335
Florida, Italian Lloyd. Attilio..... *426

PAGE

La Provence, French Line.....*221, 342
Lusitania, Cunard Line.....*233, 291
Mauretania, Cunard Line. Taylor..... *437
Nieuw Amsterdam *207
Trafford Hall. Taylor *188, 426
Steam turbine, American applications of the Curtis 19
development of the marine..... *470
compared with reciprocating engine.... *480
Steam turbines, determination of principal dimensions. Speakman. *50
in service. Riley..... 315
torsion meter for measuring power of.. *488
Steam yacht Branwen, launching of..... *317
Steel Barges. Donovan..... *214
Svip, fast launch..... *487
Thrust bearings, marine..... 27
Torpedo boat, motor-driven..... *491
Torsion meter for measuring the power of marine steam turbines..... *488
Trafford Hall, Ellerman liner. Taylor..... *188
machinery of 426
Transportation, water, its economic importance Dixon 271
Trial of armored cruiser Jules Ferry..... *367
armored cruiser Washington..... *258
battleship Louisiana. Bowen and Gregory *165
battleship Minnesota *468
battleship Nebraska *442
battleship Virginia. Bowen and Gregory. *83
Tug Poderoso, Argentine..... *128
Turbine-propelled fire boat, preliminary design *448
Turbine steamship Carmania..... *1
Kaiser. Gradenwitz *473
Viper, launch of, M'Pherson *321
Creole, twin screw..... *379
Lusitania, Cunard Line.....*233, 291
Mauretania, Cunard Line. Taylor..... *437
United States Steamboat Inspection Service, Abstracts from. Taft..... 156
Veritas, motor boat at full speed..... *263
Viper, launch of turbine steamer. M'Pherson *321
Virginia, U. S. Battleship in heavy weather. United States battleship, trial performance. Bowen and Gregory..... *83
Vulcan, steam dredger. Guarini..... *151
Washington, trial trip of armored cruiser... *258
Water Transportation: Its Economic Importance. Dixon 271
Water tube boilers in large vessels, modern practice for firing. Dinger..... *130
Winches and capstans, English and American. Perkins *178
Winter navigation on the St. Lawrence..... *20
World's Shipping 402

COLLISIONS, REPAIRS, WRECKS

Accident to the Steamship Louise..... *277
Bremen, North German Lloyd steamer at Halifax *358
Doncaster, sinking of the steamship..... *153
Flue collapse on steamship Acme..... *323
Repair of thrust shaft at sea. Smith..... *228
Repair work in dry dock at Halifax..... *358
Salving George W Elder..... *431
Stranding of steamer Alicia..... *67
Tordenskjold in collision with Euphemia....*152
Virginian, stranding of the steamship..... *153

EDITORIALS

American Ship 113
Battleship-cruisers 454
Bids for new Battleships..... 325
Big battleship craze..... 238
Delays in warship construction..... 155
Development of United States Navy..... 370
Engineers in the Navy 115
Engine Design 408
Engineering Information 409
Epidemic of Shipwrecks..... 408
Fireproof construction in steamboats 197
Fireproof steamers 454
Ineffective Armored Cruisers..... 324

PAGE

Internal combustion engines..... 493
International Marine Engineering..... 282
Lengthening of steamers..... 239
Mammoth Battleship 370
Marine Power Production..... 282
Marine steam turbines..... 492
Mauretania 455
Merchant marine 73, 114, 155, 238
Metric system 114
Motor Boat show..... 154
Naval Architects' Meeting..... 493
Naval comparisons 239
Naval engineers 30
New London Address..... 408
Our change in name..... 196
Power doors for watertight bulkheads..... 154
Powering of battleships..... 196
Printers' Strike 72, 114
Shipbuilding in the United States.....30, 238
Shipyard Management 455
Speed Supremacy of the Atlantic..... 324

ENGINEERING SPECIALTIES

Angle band saw. Crescent Machine Co.... *201
Boat davits, quadrant, Welin..... *377
Boiler tube expander. Wiedeke..... *243
Blowers, high pressure. Sturtevant..... *497
Blue printing machine. Everett-McAdam... *497
Burner, Hauck, Oil-Fuel Engine Co..... *288
Circulating pump, rotary. Brown & Sharpe. *37
Clutch, reversing, for marine engines. Holliday Mfg. Co..... *38
Composite board *243
Condenser apparatus, improved. Wheeler Condenser *122
Condenser, Contraflo *375, 497
Coupling-bolt forcer. Watson-Stillman..... *36
Drills and chucks. Rich Mfg. Co..... *36
Engine, Sheffield single cylinder four-cycle marine. Fairbanks-Morse *160
Filter, Milne. *78
Floor plates, wrought steel. Sligo..... *457
Floor scraper, Little Giant. Hurley..... *331
Gasket, corrugated copper. Taunton-New Bedford *288
Gauge tester. American Gauge..... *377
Grate bar, Barker. Rohsmith Specialty Co *76
Hawse pipe. Great Lakes Engineering Works *376
Indicator, high-pressure. Lippincott..... *202
Kerosene motor, convertible. Fay & Bowen. *498
Lathe attachment for boring. Underwood & Co *77
Lock nut, helicoid. Bayliss, Jones & Bayliss. *244
Lubricator, high-pressure, automatic. Pearl Mfg. Co *287
Lubricator, Premier gas engine. Lunkenheimer *330
Milling machine, portable. Underwood.... *201
Motor, reversible valveless marine. Sittman & Pitt *330
Oil & Waste Saving Machine..... *498
Packings, metallic. Garlock Packing Co.... *123
Pipe joint, patent compression. Leigh & Son *377
Pipe threading machine. Isaw Mfg. Co. .*288
Pneumatic tools, "Thor" Independent Pneumatic Tool Co... ..... *37
Pump, exhaust operated Curtiss Water house Co *202
Pump governor, automatic Ideal Automatic Pump Governor Co. *78
Refrigerating Plant on Creole Linde... *415
Roller Bearing for Thrust Bantam *497
Roller bearing for Marine Railways. Bantam *416
Search-light, Yale submarine electric Chicago Pneumatic *161
Smoke box door, Silley's patent *161
Steam engine, Boston Engine Co. *36
Tiling hinotile and rubber Anchor Tile Co. *285
Tube cutter, ideal self feed. Wiedeke *241
Vertical engines, Sturtevant *77

PAGE

Water alarm columns, high and low. Binghamton Machine Co. *457
Watertube boiler, patent, Riley. *376

PARAGRAPHS

American Merchant Marine. *217
Boiler Tube question. 29
Civil service examinations. 18, 121, 203
Common sense vs brute force. 305
Cost of building ten English cruisers. 362
Developments in warship designs. 490
Dreadnought in recent trial. 449
Dry Dock Dewey. 322
Dry Dock in Central Africa. 180
Engineering and Machinery Exhibition. 441
Forced draft. 113
Gunnery, World's record in. 237
Hamburg-America Line contract, reported. 341
Institute of Marine Engineers. 263
Iron and steel hull steam vessels of the United States. 20
Launch of floating dry dock. 6
Liverpool Steamship Owners' Association, annual report. 333
Lloyd's shipbuilding returns. 124, 262, 369
Made in Germany. 333
Mallory Steamship Line, sale of. 467
Mammoth Stern Frames. 290
Manchuria and Mongolia ashore. 417
Manufacture of Ships. 262
Merchant Marine League prize. 407
Moran Bros. Company, sale of. 182
Motor Boat Show. 489
Munroe Method of Making Manholes. 202
National Motor Boat Show. 489
New Shipping Lines. 205
Obituary. 111, 164, 205, 405, 468
Oil fuel for warships. 25
Over sea trade of the United States. 367
Personals. 50, 71, 163, 205, 271, 333, 349, 378, 460 487
Progress of naval vessels, 6, 50, 113, 145, 190, 270, 294, 340, 405, 441. 472
Repeal of registration act covering foreign wrecks. 141
Safety of Alcohol. 436
San Francisco catastrophe. 244
Screw propeller repairs. 281
Shipbuilding reports, Bureau of Navigation, 124, 139, 205, 294, 333. 354
Shipping losses first quarter of 1906. 445
Ship Subsidy Bill. 123
Steamship earnings, Cunard and Hamburg American. 214
Value of Naval Architects. 302
World's Record in Gunnery. 237

QUERIES AND ANSWERS

Air pressure for repairing water-tight compartments. 80
Automatic cut-off engines substituted for piston valve engines. 331
Beam engine, how to line up. 124
Carbonic acid refrigerating apparatus. 79
Carrying capacity of boat. 163
Coefficients of fineness. 245, 459
Combustion Chamber bracing in Scotch boiler. 204
Dense air refrigerating machinery. 245
Flywheel for gas engine. 80
Gas engine design. 79
Horsepower of gasoline engines. 289
of non-condensing engine. 245
rating in gas engines. 38
Knots, or knots per hour? 245
License to run small steamer. 38
Marine railway calculation. *163
Mean effective pressure in low-pressure cylinders. 79
Moment of inertia of beam. *458
Motor boat exhaust below water line. 417
Piston rod, size of. 39
Powering of a launch. 39
of flat bottom boats. 459
Propeller wheel, measurement of pitch. *416
Propellers for blunt form of boat. 39
Riveting of steam boiler. 39
Safety valve calculations. *204
Saturated and superheated steam. 459
Screw propellers, methods of constructing patterns and molds. 204
Speed formula of American Power Boat Association. 289
Stephenson link motion valve gear. 331
Strength of boiler to resist rupture. 204
Thickness of boiler shell. 39
Thickness of shell plating. 245
Ton used in shipbuilding, 2,000 or 2,240 pounds? 459
Torsional vibration of a propeller shaft. 204

TECHNICAL PUBLICATIONS

Album of Marine Celebrities. Howell. 244
American Stationary Engineering. Crane. 500
American Steel Worker. Markham. 417
Analysis and Softening of Boiler Feed Water. Wehrenfennig. 417
Barritt-Serviss Star and Planet Finder. Barritt. 332
Book of Boats. Cavanaugh. 244
Boring and Turning Tapers. Colvin. 499
Brazing and Soldering. Hobart. 457
Bureau Veritas: General List of Merchant Shipping. 38, 499
Catechism on Producer Gas. Wyer. 417
Directory of Shipowners, Shipbuilders, & Marine Engineers. 289
Directory of the Alumni of Stevens Institute of Technology. 457
Electric Wiring, Diagrams and Switchboards. Harrison. 123
Elementary Mechanics. Merrill. 79
Elements of Gas Engine Design. Moss. 499
Eminent Engineers. Goddard. 203
Gas, gasoline and oil engines. Hiscox. 38
Houseboats and houseboating. Hunt. 38
Indicator Hand Book. Pickworth. 289
Information Guide for Transatlantic Travelers. Preshrey. 332
Injectors. Pullen. 203
Internal Energy. Booraem. 500
Link Motions, Valves and Valve Setting. Colvin. 163
Machine Shop Arithmetic. Colvin and Cheney. 123
Management of Electrical Machinery. Crocker and Wheeler. 458
Manual of Wireless Telegraphy. Collins. 458
Marine Boilers. Bertin. 244
Marine Directory of the North Western Lakes. Beeson. 332
Marine Engineering. Wilda. 162, 417
Modern Engineering Practice. Gunsaulus. 288
Morton Memorial. Furman. 244
Motor Boat and Its Machinery Outfit. Mueller. 499
Naval Pocketbook. Clowes. 369
Notes on Heating and Ventilation. Allen. 162
Parsons Turbine Engineers' Log. Brown. 499
Pocket Book of Mechanical Engineering. Sames. 38
Record of American and Foreign Shipping. American Bureau of Shipping. 79
Schiffsschraube. Achenbach. 123
Shaft Governors. Trinks and Housum. 289
Shipbuilding Industry; Its History, Practice, Science and Finance. Pollock. 78
Steam Turbines. Foster. 417
Steam Turbines. Gentsch. 203
Steam Turbines. Thomas. 162
Steam Turbines. Zahikjanz. 289
Technical Dictionary. Deinhardt and Schlomann. 458
Theory of the Steam Turbine. Jude. 499
Things that are Usually Wrong. Sweet. 332
Transactions, American Society of Mechanical Engineers. Vol. 26. 332
Transactions, Institute of Naval Architects. Vol. XLVIII. 499
Transactions, Society of Naval Architects and Marine Engineers. Vol. 13. 332
Valve gears for steam engines. Peabody. 203
Water Softening and Treatment. Booth. 332
Wiring a House. Pratt. 458

Marine Engineering

JANUARY, 1906.

THE NEW TURBINE LINER CARMANIA.

Built by John Brown & Co., Limited, at their Clydebank yard, for the Cunard Steamship Company, the *Carmania* is remarkable as being the largest turbine steamer as yet constructed. She is further remarkable as being the first turbine vessel built for traffic between the United Kingdom and the United States. In building the *Caronia* and the *Carmania* the Cunard Company has provided two large and fine ships, which, even with ordinary machinery, would have been notable. But in fitting the *Carmania* fitted with quadruple expansion engines driving twin screws, while the *Carmania* has triple screws driven by three separate Parsons turbines. The only difference in the form of the hull is that rendered necessary by the three shafts. The center shaft is driven by a high-pressure turbine, and each of the side shafts by a low-pressure turbine, with the astern turbine at the after end, inside the low-pressure casing. The three propellers operated by these turbines are clearly shown in the illustration, an

THE CARMANIA ON TRIAL TRIP.

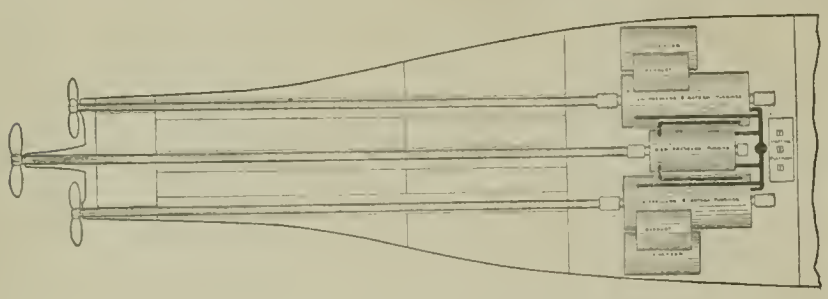
(Photograph, Journal of Commerce, Liverpool.)

with steam turbines, with the vessels identical in every other respect, opportunity will be afforded to remove all doubt as to the value of turbines as compared with reciprocating engines. They are both now running on the Atlantic, long before the two swift leviathans are ready, and from them much will be learned as to the prospects of the express steamers now building.

Except in the machinery, the *Carmania* is a sister ship to the *Caronia*, which has been already described.* The *Caronia* is important feature being that there is no outboard shaft, so that the engineer can at all times inspect the bearings, while the bossing out of the ship adds enormously to the strength. The rudder, it will be seen, is of the balanced type, the weight being 25 tons, while the bossing out of the stern above it, for the reception of the steering gear, is clearly indicated. The vessel as she stood in the ways represented a launching weight of 13,500 tons.

The keel of the *Carmania* was laid on May 17, 1904, so that only 9 months were required to bring her to the launching stage

*MARINE ENGINEERING, April, 1905, page 164.



PLAN OF THE ARRANGEMENT OF TURBINES AND SHAFTING.

THE DINING SALOON.

(February 21, 1905), and the fact that there was worked into the structure an average of 1,420 tons of steel per month indicates the splendid resources of the Clydebank establishment.

The boiler pressure in the *Carmania* is 195 pounds, in place of the 210 pounds in the *Caronia*, and the turbines take steam at an initial pressure of 165 pounds, as compared with 200 pounds in the machinery of the earlier ship. Owing to the high vacuum desirable in the turbine machinery in order to insure the fullest economy the condensing surface, which is 27,030 square feet in the *Caronia*, is increased in the *Carmania* by 20 percent, while the capacity of the centrifugal pumps is increased by about 50 percent, so that the amount of circulating water they will be capable of discharging will be from 50 to 60 times the weight of feed water, as compared with a ratio of 25 to 30 times in the *Caronia*.

The area occupied by the *Carmania's* machinery is about the same as that required for the engines of the *Caronia*, but there is a saving in weight of about 5 percent. The turbines were assembled by Messrs. John Brown & Company at Clydebank, the drums, shafting and steel castings having been manufactured at their Sheffield works, and are the largest of the kind in existence. They have 1,115,000 copper blades, each fitted separately. What most impresses one when inspecting the engine room is the enormous size of the turbine casings; these turbines, on account of having to run at such relatively low revolutions, 185 per minute, being actually four times the size of anything yet constructed; the low-pressure turbine casings are 14 feet outside diameter and 36 feet long, and to give some idea of the size of such cylinders, the low-pressure cylinders of the largest Atlantic liners at present running are 9 feet 4 inches in diameter by 6 feet stroke. The main shafts measure 14½ inches in diameter.

The main condensers are cylindrical, and the circulating water is supplied by two powerful centrifugal pumps, each of the pumps having two engines in connection therewith. Every detail in the steam plant is of a type to insure a high economy, as well as reliability in working.

The boiler installation includes eight double-ended and five single ended boilers, working in all cases at a pressure of 195 pounds per square inch. These are arranged in two separate boiler rooms, and the exhaust gases pass through two elliptical funnels, which rise to a height of 135 feet above the level of the furnace. The boilers are fitted with Howden's heated forced draught, supplied by two large fans, each driven by two engines.

THE MUSIC AND DRAWING ROOM.

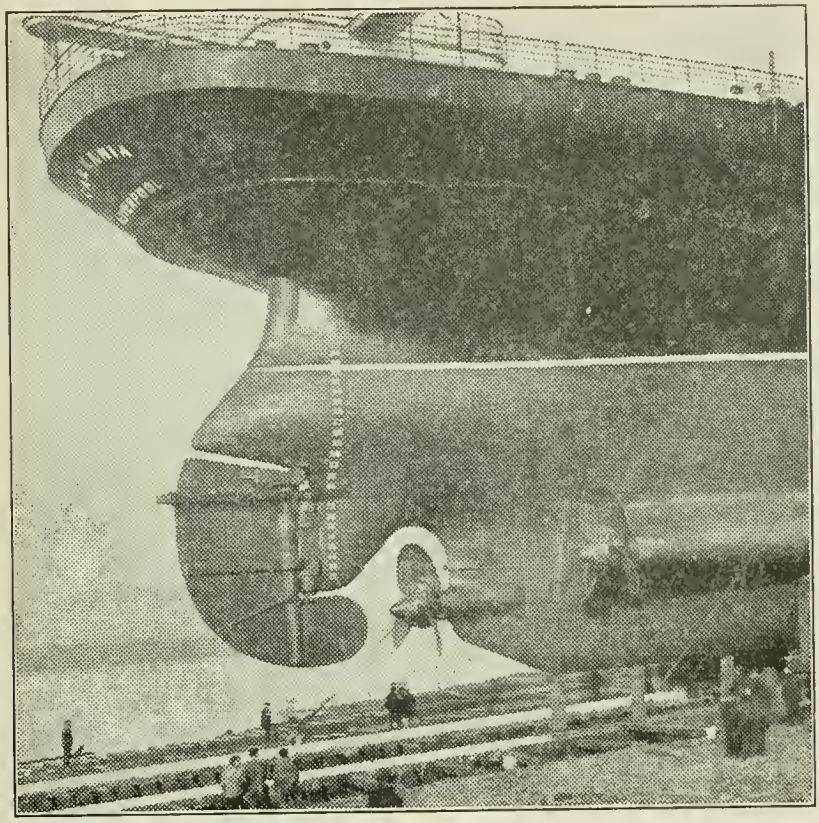
In this vessel the principle of driving the auxiliary machinery by electric motors has been developed to a considerable extent, and special attention has been given to the disposition of fans for the ventilation of the extensive passenger compartments. The navigating and deck machinery is necessarily of a powerful character. There are two steering engines of very heavy proportions, one under the waterline, so that there is little chance of this important item of the navigation of the ship being affected by gunshot when the vessel is used as an armed cruiser; the other steering engine is placed on a higher level. The rudder stock is extended up to the highest gear, but can be operated by either of the two steering engines. The capstan and windlass gear for working the heavy anchors are probably the heaviest that have been

fitted to any merchant ship. The navigating bridge is placed in a very high position, so as to command a wide circle, and the captain has, within arm's reach, apparatus whereby he can control every movement, both at sea and while entering docks.

The ship is of the following dimensions:

Length over all	678 feet
Breadth molded	72 feet
Depth to shelter deck	52 feet
Draft of water laden	32 feet
Corresponding deadweight cargo	12,000 tons
Displacement	29,800 tons
Gross tonnage	19,524 tons

one, two, or three passengers. A number of them are *en suite* with bathroom, while the more pretentious ones consist of bedroom, parlor, bathroom and toilet room. The *en suite* rooms are large and fitted with wide berths, ivory white paneling, velvet pile carpets, luxurious settees and armchairs, dressing tables, wardrobes, writing tables, bookcases and hot and cold water. Most of the staterooms are fitted with a spring sofa, a Pullman upper berth, and a wide lower berth, dressing table, wardrobe, writing table and easy chair. The berth curtains are of finest damask, and the carpets laid on the deck are a rich shade of red, which imparts a comfortable and cheerful appearance to these apartments. The rooms are well lighted, and the passenger can, at will, have a light at almost any place convenient to himself.



THE SHIP'S STERN BEFORE LAUNCHING.

There have been used in her structure 1,800,000 rivets and 12,000 tons of steel. Some of the plates are 32 feet long, secured by five lines of rivets; the keel is three inches in thickness; and there is a double bottom for water ballast to bring the ship to a draught that will obviate rolling or pitching. The total capacity for water ballast is 3,450 tons. Very deep bilge keels have been fitted for one-half the length, and there are twelve bulkheads across the ship, so designed that if any two of the compartments were flooded the ship would continue to float. The bulkhead doors are closed by the Stone-Lloyd system. The stern frame of the *Carmania* is a forging, weighing about fifty tons. She is built on the shelter deck principle, with eight decks, and has been specially built for the highest class of Lloyd's special survey, and also under direct survey to the requirements of the British Admiralty, as a transport and armed cruiser. She has two pole masts rigged on the fore-and-aft system, with derricks, spans and other appliances for dealing with cargo.

In the passenger accommodation is an admirable system of cabin distribution and arrangement. There is provision for 300 first-class passengers, 350 second-class, 1,000 third-class, and 1,000 steerage, a total of 2,650, and with 450 officers and crew, the total ship's complement will be 3,100. There are staterooms for

Electric bells are fitted at convenient points for each berth. The rooms on the upper promenade and promenade decks are fitted with electric heaters. The bathroom and toilet arrangements in the ship have received special attention, and are distributed throughout in the most convenient positions, a notable feature being the number of needle and shower baths which are fitted.

Commencing with the highest of the eight decks of the vessel —the boat deck—the first thing which strikes the visitor is the magnificent lounge, which is an innovation in this and her sister ship *Caronia*, and forms a special feature among the public rooms of the vessel. It is designed to afford a comfortable retreat, where gentlemen may smoke in the company of their lady friends, while a convenient buffet suggests possibilities in the way of tea, coffee, and light refreshments. The usual stiff ship seat in the room gives place to a luxurious divan fitted round the apartment and formed into nooks and bays. Easy chairs with comfortable head rests are supplied, and the general effect of the blue furnishings with the rich coloring of the Eastern rugs and subdued tone of the mahogany fittings, combine to produce an effect of elegance.

Underneath this is the upper promenade deck, and leading off the spacious main entrances are situated the writing room and

drawing room. The writing room is an exceedingly tasteful apartment, with the ceiling and bulkheading treated in delicate Adams style, all painted and finished ivory white, with the rich and luxurious furnishings carried out in a restful shade of soft green. The room, as its title implies, is fitted for writing purposes only, and the tables are designed with a view to securing for each person the privacy of one's own sanctum. Passing from the writing room through archways draped with sumptuous velvet hangings, the drawing room is reached. This room is also carried out in the Adams style, with the bulkheading exquisitely paneled and molded, broken by pilasters richly carved and fluted. The whole ceiling and bulkheading is finished in ivory white, with rose silk panels. The furniture of the room is carried out in dark mahogany. The rich carpet is of a soft green shade, and the settees and easy chairs are upholstered in velvet of delicate rose and green. A charmingly-designed mantelpiece, with hammered brass sides and canopy, adds to the interest of the room. The deep oriel bays at each side, with their inviting settees, easy chairs, and cosy corners, all tend to suggest that the passenger is at home rather than voyaging across the Atlantic. The aim of the designers has been to get away from the usual and stereotyped style of drawing room aboard ship, with its rows of stiff and uncomfortable seats. The silk hangings and silk panelings are exquisitely fashioned. The room is flooded with soft light from the flat circular dome above, with its tastefully designed leaded glass panels, quite in accordance with the decorations.

The first-cabin smoking room, which is aft on the same deck, is a room of more than usual distinction. The style employed is Elizabethan, and the result is most dignified and pleasing. The paneling is carried out in fumigated oak, with enriched and carved pilasters and pillars. The deck is laid with parquet, and the ceiling paneled in deep cream with oak molded beams. Rising from the ceiling in the center of the room is a flat-roofed dome with the sides paneled and carved and relieved by lacquered gold panels. The center of the dome is fitted with leaded lights, and the flat of the dome is picked out in gold. Here again the designers have effectively striven to produce a home-like effect, and the well-proportioned mantelpiece, with hand-beaten copper grate and open fireplace, which is surmounted by a semi-circular panel of hand-beaten copper, form a feature which is seldom met with on board ship. An unusually large assortment of easy chairs and lounges completes the furniture of this room, which has more the appearance of a comfortable living room in a country house than an apartment aboard ship. The upholstering is in mellow colors, which blend perfectly with the surroundings. The room is thoroughly lighted, not only from the square port windows on either side, but by the handsome skylight above.

The dining saloon, which is two decks beneath this, is arranged amidships, and extends the full width of the vessel, accommodating 300. The style employed in the decorations is Georgian, and the paneling to the room is all painted and finished ivory white. In the center of the room a large octagonal dome is arranged with the sides opening out on to the alleyways on the deck above; the sides, pillars, and ceiling of this dome are decorated in ivory white and enriched with gold, which forms a pleasing relief to the remainder of the saloon. The same decorative scheme, but in a higher relief, is shown in the frieze surrounding the entire saloon, which harmonizes perfectly with the capitals of the columns. Instead of the unbroken lines of tables fore and aft of the ship, these are broken up into small tables to suit parties of six, eight, ten, or twelve, as the case may be, with a circular table in the center of the saloon. The chairs, too, have had special attention, and instead of the usual heavy revolving chairs, there are fitted thoroughly comfortable chairs with shield backs. The floor is laid with polished oak parquet, and between the tables are laid runners of thick Wilton carpet, which tones with the rich wine color of the upholstery. The outlines of the room are broken by a number of alcoves, formed by graceful arches and pillars.

THE LOUNGE, ON THE BOAT DECK.

On the promenade deck, conveniently located, is a polished mahogany counter, in semi-circular form, surrounded by an ornamental brass railing and serving the purpose of the customary hotel office. In this department is a steel-lined safe-deposit vault, containing a safe wherein travelers' valuables may be deposited. Near here is a stenographic room, in charge of a stenographer. Throughout this deck, as well as the others, are to be noted the spaciousness of the passages and the breadth of the stairways. There is on this deck the barber shop, handsomely equipped, the doctor's room and consulting rooms, and other conveniences for passengers' uses.

The second-class accommodation is hardly inferior to that provided for first-class passengers. Indeed, the saloons and staterooms on this vessel are undoubtedly an improvement from all points of view on the first-class accommodation fitted on many vessels now plying across the Atlantic. The dining saloon is paneled and finished in ivory white, with soft blue coverings to the seats, and blue carpets. There is a handsome sideboard fitted at the forward end, and at the after end is a handsome piano. The chairs are set on revolving standards, and the general effect is most pleasing. This room also extends across the entire width of the ship, insuring both light and ventilation from the large square ports.

THE CARMANIA IN FREE ROUTE.

Immediately over this room are the second-cabin drawing and smoking rooms, provided with every comfort found in the first-class apartments, and different only in the degree of their luxuriousness. The drawing room is carried out in satinwood neatly paneled and treated in simple but effective manner with carved pilasters. The second-class library is located in this room, and is kept well supplied with the latest publications. This room also forms the writing room, and neat writing tables and armchairs are arranged. The seats and easy chairs are upholstered in blue tapestry, and the floor laid with soft blue carpet, which tones well with the quiet gold of the satinwood paneling.

The smoke room is fitted in mahogany, with seats covered in blue moquette arranged in bays round the room; deep easy chairs, armchairs, and tables are also fitted, and the room, with its carpet runners and rich mahogany paneling, presents an appearance at once comfortable and luxurious. The staterooms are arranged in two and four-berth rooms, with fittings similar to those of the first-class staterooms; the rooms are notable by reason of their size, and are fitted with wide spring berths, comfortable sofas, fold-up lavatory fittings with dressing glass above, large wardrobe well supplied with hooks, berth curtains of cheerful patterned material, and carpet of rich red color.

It is open to question whether greater improvement has not been made in the third-class accommodation than in the first and second classes. A fine dining hall is fitted amidships to accommodate 500 persons at once. The sides are paneled with American ash and a teak dado. The tables are fitted with revolving chairs, and a piano, sideboard, etc., are provided. There are smoke rooms fore and aft, ladies' rooms fore and aft, all paneled to accord with the dining hall, and fitted with comfortable lounge seats and tables. The stateroom accommodation is provided in two-, four- and six-berth rooms, all large and airy rooms, provided with washstands, dressing glasses, seats and hooks. Arrangements are made by which the whole of the air in the third-class passenger spaces will be changed entirely every five minutes; with this great advantage, that in cold weather the fresh air will be warmed and in hot weather the air will be cooled by a special process. The sanitary arrangements are ample and of the latest and most up-to-date description. Baths are provided on a scale not before attempted, and in addition there are a number of shower baths for the use of the men, an innovation which was carried out in the *Caronia,* and which has been an undoubted boon to the third-class passenger.

Victualing is one of the most important items at sea, and the arrangements on the *Carmania* are as perfect as can be. The galley is the largest yet made, and every device which science has evolved has been requisitioned to secure to the passengers that the food supplied shall be well cooked. Perfect cleanliness is everywhere aimed at, and in no department is this so noticeable as in those where food is prepared and served. Potatoes are peeled by machinery, and thus handling is obviated. Dishes are washed by mechanical means, three Vortex plate-washing machines, capable of dealing with 8,000 pieces an hour, being provided for this purpose. In latter-day culinary methods steam

THE FIRST-CABIN SMOKING ROOM.

enters very largely into cooking processes for vegetables, etc., and to insure that the steam used in the galley of the *Carmania* shall be absolutely free from contaminating matter, which might occur in steam taken from the main boilers, a separate steam generating plant is provided in the galley. The same cleanliness obtains in the baker's shop, in the pantry, and the fact is characteristic of the whole of the cuisine arrangements for passengers. Among other devices which are to be found in the galleys are machines for making sandwiches, for cutting bacon, and also for boiling eggs. Some difficulty has hitherto been experienced in providing passengers on shipboard with fresh toast, but on the *Carmania* this has been overcome by the provision of a special toasting fire, which is quite a novelty. Testimony to the efficiency of the fittings of the cuisine department is afforded by the fact that the kitchen and cooking plant have been supplied by Henry Wilson & Company, of Cornhill, Liverpool, a concern which holds the remarkable record of having fitted every first-class British-owned passenger steamer built for the Atlantic trade during the last twelve years.

The latest safety device to be incorporated in the *Carmania* and other Cunard ships is the new system of submarine signaling. It is electric and telephonic, and by it signals can be transmitted under water between steamships and light vessels or from ship to shore. These signals work perfectly in cases of fogs when visual signals are useless. Many lightships are being equipped with submarine bells, and in thick or foggy weather these sound continually the known signal of this particular vessel. Approaching steamships provided with this apparatus are enabled to ascertain their exact location at all times and under all conditions. The sound of the bell, as heard on the steamship, indicates its direction and—by the intensity—its approximate distance, water being a constant medium.

An approved system of forced draught is adopted, as well as noiseless ash-lifts and various other features. The illumination of the ship is, of course, by electricity. To do this four large dynamos of 750 amperes and 100 volts are required, and the light is transmitted through more than 3,000 individual lamps and a powerful searchlight. Another important installation is the refrigerating machinery and cold storage. This is one of the largest plants ever placed on board ship, was installed by the Liverpool Refrigerating Company, and is operated on the ammonia system.

As the *Carmania* marks a new epoch in the Cunard Company, we note below the various stages of development in the fleet:

	Date	Make	Length	Tons	H.P.
Britannia	1840	wood	207	1,154	740 paddle
Persia	1855	iron	376	3,300	4,000 "
China	1862	"	326	2,539	2,850 screw
Servia	1881	steel	515	7,392	9,900 "
Lucania	1893	"	600	12,952	26,000 twin screw
Carmania	1905	"	675	19,524	20,000 turbine

The *Carmania* completed her trials on the Clyde in the third week of November, 1905, before proceeding to Liverpool to load. The completion of these trials renders possible a direct comparison between the marine steam turbine as fitted in the *Carmania* and the reciprocating engine, as fitted in the *Caronia*, which has now been running on the Atlantic for some time. In this respect they may be called epoch-making vessels, from which naval architects and engineers will be able to draw many lessons.

The trials on the Firth of Clyde consisted of four runs on the measured mile at Skelmorlie, and a six hours' run. The contract required that a speed of nineteen knots should be maintained on the latter. On the four runs on the mile the speed was 20.19 knots, although the ship had not been docked since she was launched in February, and was very foul below the waterline. Allowing for that, the *Carmania* is fully 1½ knots in excess of the guaranteed speed, and one knot in excess of the *Caronia*. The contract further required that after an interval, determined by the directors of the company, the vessel should run a second six hours' continuous trial at contract speed, and this trial the *Carmania* steamed on the Firth for the stipulated time, the distance being measured by chart. High speed was not aimed at, and the rate all through was a little over 19 knots.

The *Carmania* steamed more easily than the *Caronia*, yet the machinery of the *Caronia* was a development of that of the *Saxonia*, proved by the Naval Boiler Committee to be the most economical steamer then afloat. If the *Carmania* improves on the *Caronia's* economy, she will be a very economical vessel. In maneuvering, the *Carmania's* efficiency was proved by the incident of a slight mishap to the steering gear, when the propelling machinery only was available for steering purposes, and the ship was satisfactorily steered by means of the turbines. On the measured mile trials at full speed the turning circle of the *Carmania* was considerably less than that of the *Caronia*. There was an instrument for testing not only horizontal but also vertical vibrations, and the records taken showed that the vibration in the *Carmania* was exceedingly slight.

The ship left Liverpool on her maiden voyage December 2, 1905, and reached New York December 10, having made the passage in 7 days 9 hours 31 minutes, or at the mean rate of 15.97 knots for the 2,835 miles.

Progress of Naval Vessels.

The Bureau of Construction and Repair, Navy Department, report under date of December 10, 1905, the following percentage of completion of vessels building for the United States Navy:

			Nov. 1.	Dec. 1.
BATTLESHIPS.				
Virginia	19 knots.	Newport News Co.	95.31	97.
Nebraska	19 "	Moran Brothers Co.	82.	83.
Georgia	19 "	Bath Iron Works.	89.	90.15
New Jersey	19 "	Fore River Shipbuilding Co.	92.1	93.7
Rhode Island	19 "	Fore River Shipbuilding Co.	95.	98.
Connecticut	18 "	Navy Yard, New York, N. Y.	91.3	92.66
Louisiana	18 "	Newport News Co.	89.25	92.56
Vermont	18 "	Fore River Shipbuilding Co.	65.8	68.7
Kansas	18 "	New York Shipbuilding Co.	64.9	67.7
Minnesota	18 "	Newport News Co.	75.41	77.1
Mississippi	17 "	Wm. Cramp & Sons.	43.31	45.74
Idaho	17 "	Wm. Cramp & Sons.	39.19	42.58
New Hampshire	18 "	New York Shipbuilding Co.	28.	29.2
ARMORED CRUISERS.				
California	22 knots.	Union Iron Works.	84.3	86.2
South Dakota	22 "	Union Iron Works.	83.2	84.9
Tennessee	22 "	Wm. Cramp & Sons.	87.8	90.02
Washington	22 "	New York Shipbuilding Co.	87.9	89.4
North Carolina	22 "	Newport News Co.	23.13	26.77
Montana	22 "	Newport News Co.	19.21	22.29
SEMI-ARMORED CRUISERS.				
St. Louis	22 knots.	Neafie & Levy Co.	81.28	83.62
Milwaukee	22 "	Union Iron Works.	84.01	86.
SCOUT CRUISERS.				
Chester	24 knots.	Bath Iron Works.	9.	13.27
Birmingham	24 "	Fore River Shipbuilding Co.	12.6	15.4
Salem	24 "	Fore River Shipbuilding Co.	12.3	14.8
SUBMARINE TORPEDO BOATS.				
Submarine No. 9		Fore River Shipbuilding Co.	30.6	43.5
" " 10		Fore River Shipbuilding Co.	29.	36.9
" " 11		Fore River Shipbuilding Co.	29.3	37.
" " 12		Fore River Shipbuilding Co.	25.	33.6

There has just been launched at Orange, Texas, a floating drydock in a single-box section, the length over all being 332 feet; the length of the box, 242 feet; the width, 95 feet; depth of box, 14 feet; depth of water over entrance sill when submerged, 23 feet; capacity, 5,000 tons. This was built by the New Orleans Dry Dock and Shipbuilding Company, and will be operated by them at New Orleans. It has been built of the finest quality of yellow-pine timber in long lengths averaging about 60 feet. The logs for this timber were cut by the Latcher & Moore Lumber Company, and floated down the Sabine River from Calcasieu County, La.

THE EVOLUTION OF THE LIFEBOAT.

BY CAPT. C. H. M'LELLAN, INSPECTOR AND SUPERINTENDENT OF CONSTRUCTION, UNITED STATES LIFE-SAVING SERVICE.

The self-righting and self-bailing lifeboat of to-day is not a recent invention, as many magazine and newspaper articles of recent date would lead one to suppose. The origin of the lifeboat, or a boat especially designed to save life, dates back to the year 1785, when one Lukin, a coach builder, of London, built a boat having a deck with air spaces below the deck and at the sides and ends, with projecting gunwales of cork, and an iron keel to give it the desired stability. Several boats were built from Lukin's design, and are reported to have saved many lives on the English coast. The boat was not self-righting nor self-bailing. Lukin died in 1834 at Hythe, Kent, England, and the following inscription is still to be seen on his tombstone in Hythe churchyard:

> "This LYONEL LUKIN was the first who built, and was the original inventor of that principle of safety by which many lives and much property have been preserved from shipwreck; and he obtained for it the King's patent in the year 1785."

No great improvement was made upon the Lukin boat until the year 1852, when, because of many wrecks and much loss of life on the English coast, the Duke of Northumberland offered a prize of one hundred guineas for the best model of a lifeboat, and five officers of prominence of the line and construction corps of the Royal Navy were selected as judges. Two hundred and eighty models were sent in from the United Kingdom, France, Holland, Germany and the United States, to compete for the prize, which was won by Mr. James Beeching, of Great Yarmouth, his model being of the self-righting and self-bailing type. The judges, however, were not entirely satisfied with the Beeching boat, and requested Mr. James Peek, assistant master shipwright of the Woolwich dockyard, to examine the various competing designs once more, and to embody as many of the good qualities of the best plans as possible, into a new design, and the present 34-foot self-righting, self-bailing lifeboat is the result, with such improvements as the years of service since have suggested.

When the United States Life-Saving Service was reorganized in 1872, one of the self-righting lifeboats was purchased from the Royal National Lifeboat Institution of Great Britain, and the lifeboats of the service have since been built practically upon the same principle, with some minor changes which are considered improvements.

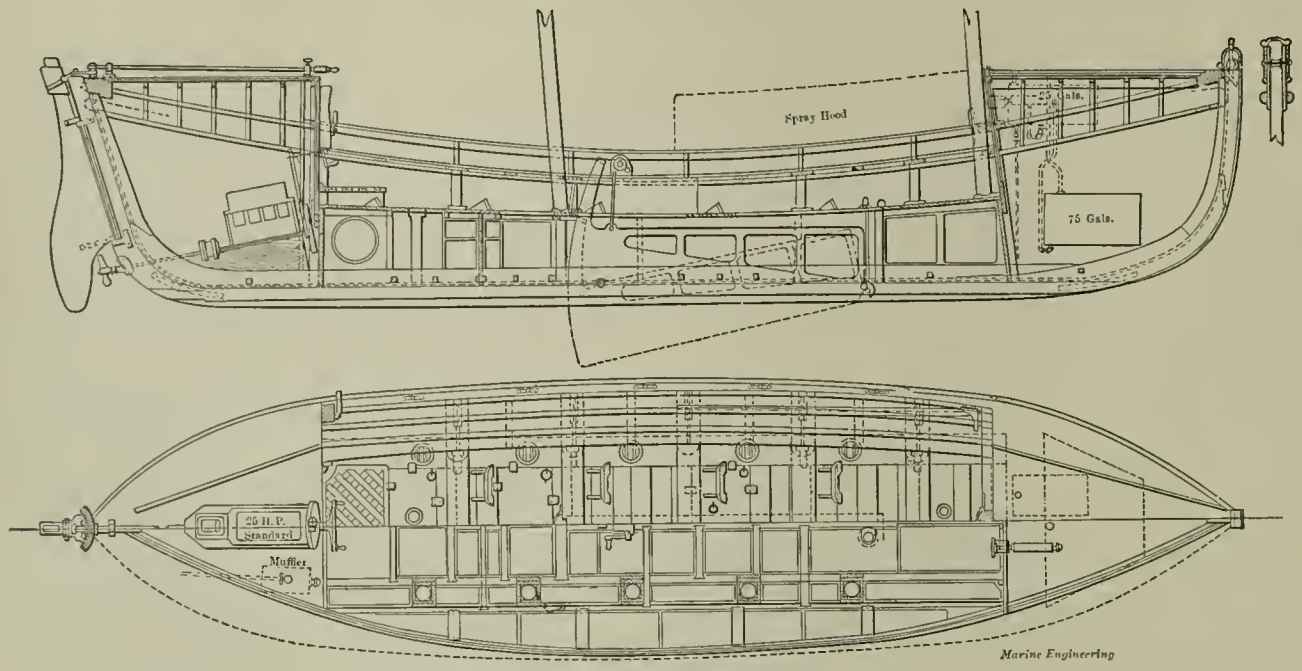
A lifeboat should combine the following qualities to the greatest degree possible: Extra buoyancy, stability, self-bailing, self-righting, passenger accommodation, strength, speed; and no boat has yet been brought to the attention of the officials of the Life-Saving Service which combines in so great a degree the above qualities, as the 34-foot service lifeboat recently completed by the Electric Launch Company, of Bayonne, N. J., from plans furnished by the government.

This boat is made unsubmergible by means of a deck at the load waterline, and three cross bulkheads and two longitudinal bulkheads below the deck, the watertight spaces within these bulkheads being completely filled with copper air-tanks, eighty-two in number. Additional buoyancy is also obtained from the end air cases, which, though chiefly intended to assist in the self-righting quality, will alone support the boat if it be filled with water, and also from the side air cases on deck under the side thwarts, which are intended to throw any water coming on board to the amidships emptying tubes. It is estimated that the buoyancy of the end air cases above the line of flotation is 4½ tons; that of the side air cases on deck, 1½ tons, and of the spaces below the deck, 5½ tons. A load of forty-four men taken from the works of the builder brought the deck scuppers awash.

THE BOAT UNDER SAIL, WITH PROTECTIVE HOOD IN PLACE.

Lateral stability or stiffness is of more importance in a lifeboat than in any other type of boat, since, from its work in the surf, it is more exposed to the risk of upsetting. This is obtained in the boat in question by the outside gunmetal keel before referred to, the gunmetal centerboard and the copper tanks in the air spaces below the deck. The end air cases or chambers also offer strong resistance to an upset when the boat is thrown on her beam ends. These, with a long, flat floor, give the boat greater stability than any other boat of its size that has ever come under the observation of the writer. In recent tests it required 3,300 pounds of pig lead, placed upon the gunwale, to bring the gunwale awash.

The self-bailing or discharge of the water is a peculiar feature of this lifeboat, enabling any water which may be shipped over the rail or taken on board by being thrown on her beam

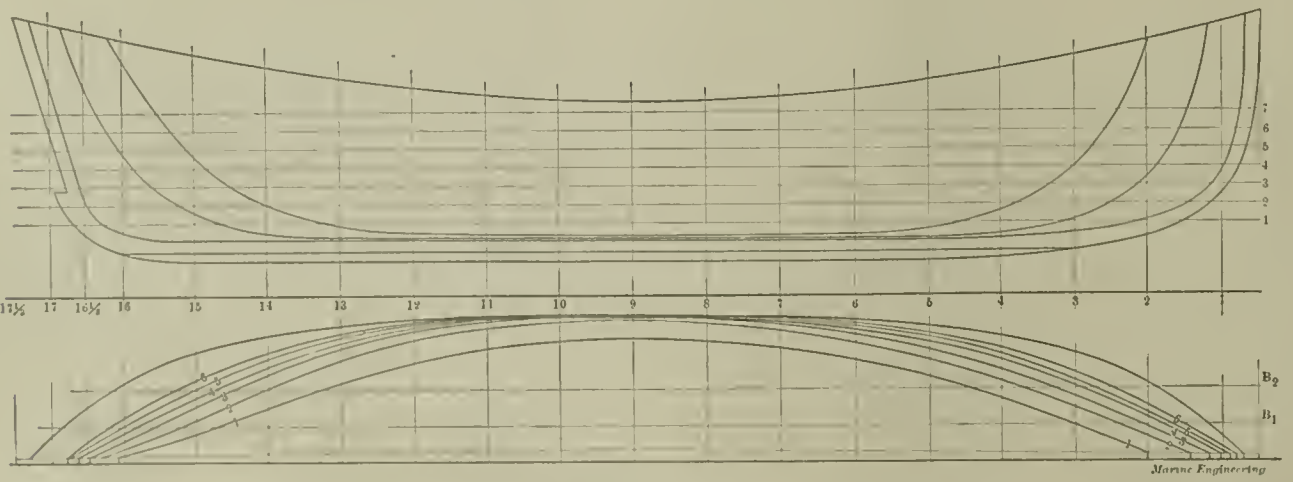


INBOARD PROFILE, AND ARRANGEMENT PLAN OF NEW LIFEBOAT.

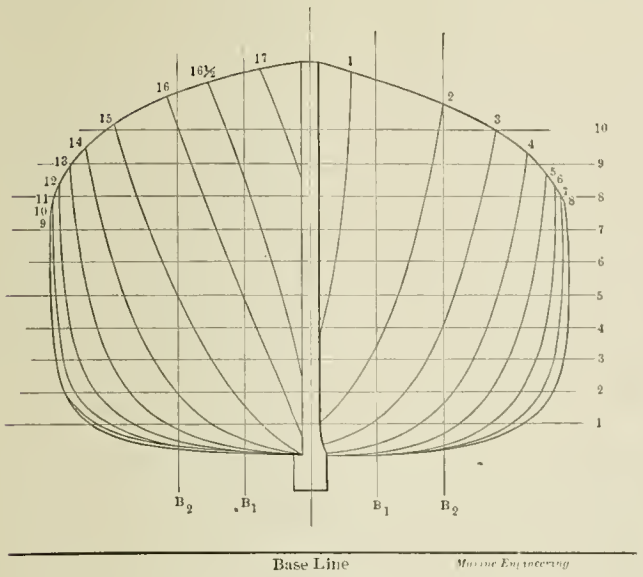
ends, to escape overboard in a few seconds. This self-bailing quality is accomplished by a deck placed above the load water-line, and ten six-inch copper tubes, five on each side of the deck, opening on the outside of the bottom of the boat, the upper ends at the deck being fitted with self-acting valves. These valves have a plate fitted in the upper ends of the tubes, turning upon an axis on one side of its center, so balanced as to remain shut of itself, the larger half seating against a shoulder above the valve, and the smaller half having its seat below the valve, so that it is opened by the slightest weight of water upon the larger half from above, and shuts still closer from any pressure of water or air from below.

The boat is made self-righting by giving it considerable gunwale sheer, two feet four inches amidships, and by air cases or chambers at each end, six feet long, of the height of the ends, and continuing their length parallel with the waterline, having sufficient cubical contents from the thwarts upward to bear the whole weight of the boat when inverted or bottom up in the water. When the boat is forcibly held in the water with the keel uppermost, it is floated unsteadily on the bow and stern air cases, while the heavy gunmetal keel, weighing 1,050 pounds, the metal centerboard weighing 750 pounds, and the copper air cases in the hold weighing 900 pounds, being then above the center of gravity, effects an unstable equilibrium, and the weight, falling on one side or the other of the center of gravity, rights the boat to her ordinary position; while the water shipped during the upset is thrown amidships by the side air cases and quickly escapes through the eight bottom bailing tubes. The raised end air cases or chambers are a great factor of safety to a lifeboat by preventing all water or other weights from loading the boat at either end, and by keeping water from breaking over the boat at the bow or stern, and giving a great resisting power to the submersion of the ends. The arrangement of the air cases forming the extra buoyancy is such as not to interfere with the passenger carrying properties of the boat.

There is no other boat of its size that is exposed to such hard usage as a service lifeboat. It is liable to be thrown heavily upon the beach or rocks, or against a vessel's side, or to come in contact with floating wreckage. To guard against serious injury from such causes, no pains or expense are spared in its construction. The specifications call for the very best material and workmanship. The best of white oak is used for the keel,



THE LINES AND BUTTOCKS.



THE BODY PLAN.

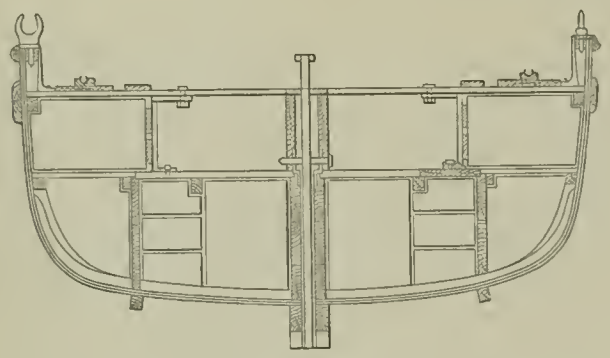
keelson, stem and stern posts, the latter, root knees. The planking is of ⅜-inch clear Honduras mahogany in two layers, laid diagonally across each other throughout at an angle of 45 degrees with the keel amidships, each plank not to exceed seven inches in width, and extending in one length from gunwale to gunwale on opposite sides of the boat to within eight feet of each end, and thereafter in one length from rabbet to gunwale.

keelsons, one on each side, of 1½-inch yellow pine, extending the whole length of the space between the end air cases, from the skin to the deck, forming longitudinal watertight bulkheads. Three athwartship bulkheads of the same material are dovetailed into these bilge keelsons. The spaces between the bulkheads and bilge keelson, and between the skin and deck, are filled with

BOW VIEW OF BOAT UNDER SAIL.

THE BOAT UNDER POWER, WITH PROTECTIVE HOOD FURLED.

Between each two layers of planking is a covering of 10-ounce cotton duck laid in white lead and oil, and both layers of planking copper riveted through and through. The outside keel is bolted through the keelson and planking with composition bolts, and below the keel is bolted the gunmetal keel, three-inch deep siding like the wooden keel. A strong feature of the construction is the fenders of white oak, six inches wide and two inches thick in one length, extending from stem to stern, fastened through and through the risings. There are two inside bilge eighty-two close-fitting, watertight, copper tanks, shaped to the spaces they occupy, all of which can be removed through the hatches in the deck. The deck is of mahogany, laid in the most substantial manner. The centerboard is of gunmetal. There are two hollow spruce spars, with sprits, sails and one jib, and ten 15-foot oars, double banked. A unique steering gear is so arranged that it can be instantly disconnected from the rudder head, permitting of the rudder being hoisted out of the water by a purchase always in place, thus enabling the boat to be



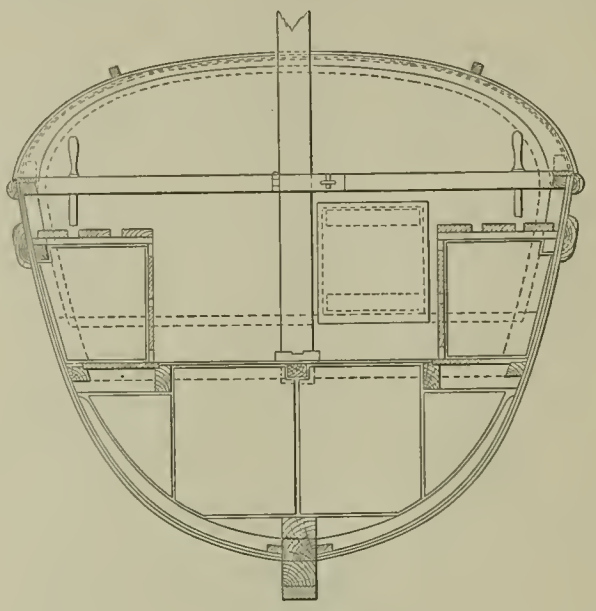
Section Amidship *Marine Engineering*

steered by sweeps when entering a broken surf where it would be unsafe to steer by the rudder. A spray hood for protection in freezing weather covers a portion of the deck, and folds snugly against the forward air chamber when not in use.

In addition to the above means of propulsion, a gasoline automotor has recently been installed. The officials of the United States Life-Saving Service have been prompt to recognize the advantage in power and lighter weight afforded by the gasoline automotor, and are installing them in the 34-foot class of self-righting service lifeboats described above. This class of boat is about the maximum in size and weight that can be advantageously handled by the regular crew of a life-saving station with oars or sails, and to install a heavy motor in them would necessitate either increasing the dimensions of the boat to an unmanageable size, or reducing the passenger capacity of the boat. Several of this class of lifeboats were fitted with the ordinary gasoline engines several years ago, and while they have been a pronounced

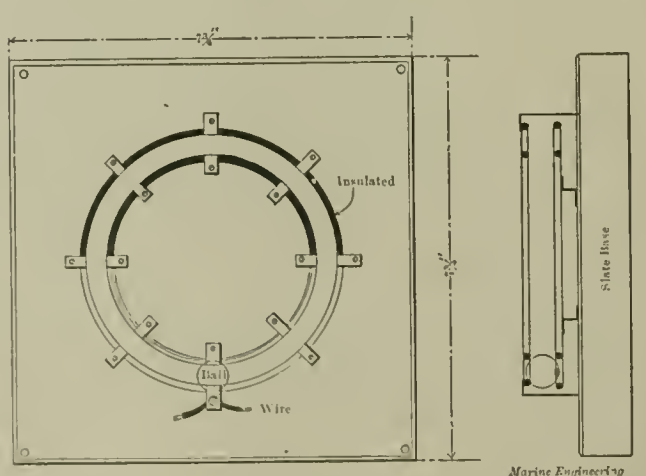
QUARTER VIEW, BOAT AT REST.

improvement and have added greatly to the efficiency of the boat, the loss in carrying capacity, because of the great weight of the motor, has been severely felt. At the time the boats above referred to were fitted with the gasoline engines, the lightest 12-horsepower engine obtainable was about 1,200 pounds in weight, which with the fittings amounted to nearly 1,500 pounds. At the present time the same class of boat is being equipped with a 25-horsepower "Standard" automotor which, with its fittings and fuel, has a weight of less than one-half of the old equipment, and with a large increase of revolutions and speed. This motor is installed in the after air case, and drives an 18-inch three-bladed propeller 900 revolutions. The main fuel tank, holding seventy-five gallons, is in the bottom of the forward air case, with an auxiliary tank holding twenty-five gallons in

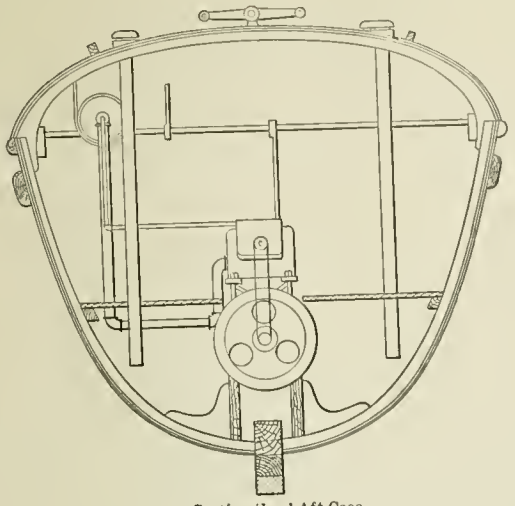


Section at Fwd.Blk'hd *Marine Engineering*

the top of the same case, into which the fuel is pumped as needed from the main supply. This arrangement carries the principal weight of the fuel low down in the boat, while the height of the auxiliary tank gives sufficient fall of fuel to the motor in the roughest sea. The fuel is led to the motor through a brass pipe let into the keel outside of the boat. All of the attachments for running the motor lead to the outside of the bulkhead of the after air case, and are protected in sleeves from accident by rope, oars, etc. In case of an upset, the motor is automatically stopped by breaking the circuit of the sparker, by an ingenious device designed by the Electric Launch Company, and shown in the accompanying diagram. It consists of four metal rings forming a circular cage upon a slate base in which travels a brass ball. As this circuit breaker is placed in the boat on a vertical plane, the top section is insulated from the lower section, the amount of insulated area depending upon the angle at which it is desired to have the ignition circuit of the motor cut off, and, therefore, can be varied as required. In the case of the boat in question, the upper half is insulated, the lower half uninsulated, and in this section the ball travels. The ignition circuit of the motor is so arranged as to have this cage in series with the battery and sparking points. In case of an upset when the boat is upon her beam ends, the ball rolls to the insulated portion and, therefore, opens the ignition circuit. The electricity is conducted through the metal ball and rings. As far as we know, this is the first time this form of circuit breaker has ever been used,

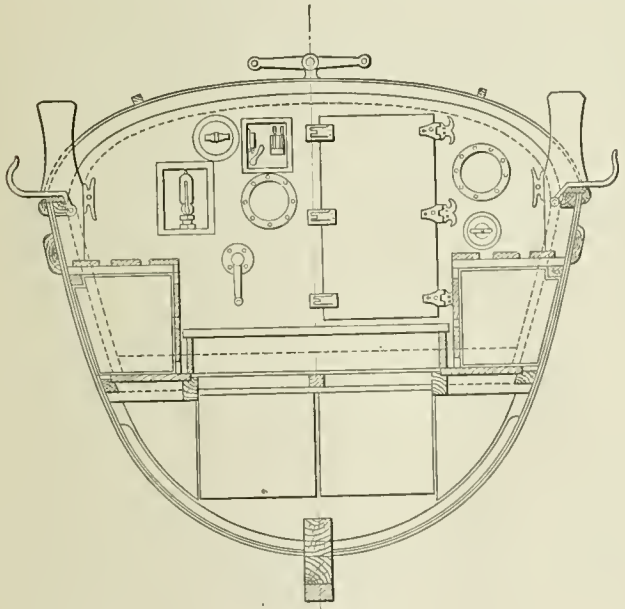


THE CIRCUIT BREAKER.



Section thro' Aft Case *Marine Engineering*

and we believe it the simplest scheme that has yet been devised. In the capsizing tests made with the boat, in which a crane was necessary to throw it over, the motor was running at full speed, and upon reaching the quarter point or on its beam ends, the circuit breaker stopped the motor. The boat being thrown bottom up instantly self-righted and emptied itself, and the motor was again started as soon as a man could reach the starting crank.



Section at Aft Blk'hd *Marine Engineering*

Recent tests of this boat for speed, endurance and carrying capacity have been most satisfactory, and it is believed that the present boat is as completely equipped for the work of the Life-Saving Service as it is possible to make it.

Proposed Legislation for the Merchant Marine of France.

The shipping law of 1902, which was intended to ameliorate the condition of the French merchant navy, has given but little satisfaction to either the ship owners or the shipbuilders of France. Although the life of the law was fixed at ten years, during the three years it has been in operation the maximum tonnage prescribed has already been registered, so that during the rest of the period the law will give no encouragement to build new vessels, as they cannot enjoy its benefits. The result is that a great stagnation prevails in the shipbuilding yards throughout France, thousands of men are out of employment, and the upbuilding of the merchant marine is checked. To relieve this critical situation, the shipowners and shipbuilders, through their representatives, agreed upon a measure which was presented to an extra-parliamentary committee appointed by the minister of commerce. The committee, after hearing those interested in the question, prepared a bill which has been approved by the minister of commerce, and will, in all probability, be brought before the present parliament. This being a short session, however, it is doubtful whether the measure will be discussed, as most of the time will be taken up in voting the budget.

SHIPPING BOUNTY.

The principal features of the new project are the suppression of the navigation bounty and the granting of a shipping bounty (compensation d'armement) to all vessels sailing under the French flag in the deep sea or in the international coasting trade, whether foreign built or constructed in France, provided the former are over two years old when they receive their French registers. The proposed bounty, per day the vessel is actually in commission and per gross ton, is for steamers, 4 centimes (0.772 cent) per ton up to 3,000 tons; 3 centimes (0.579 cent) for each additional ton between 3,000 tons and 6,001 tons; 2 centimes (0.386 cent) for each additional ton above 6,001 tons; for sailing vessels, 3 centimes (0.579 cent) per ton up to 500 tons; 2 centimes (0.386 cent) for each additional ton between 501 and 1,000 tons; 1 centime (0.193 cent) for each additional ton above 1,000 tons.

The bounty is given to those sailing vessels only whose gross tonnage is at least 100. There is a reduction of 15 percent when steamers, on their trial trips, half loaded, do not make an average speed of at least 10 knots. No bounty is given to steamers which do not make 9 knots. The bounty is increased 10 percent for steamers making 13 knots on their trial trips; 20 percent for steamers making 14 knots; 40 percent for steamers making 15 knots, and 80 percent for steamers making 16 knots.

CONSTRUCTION BOUNTY.

To compensate the French shipbuilders for the privilege granted to the shipowners to buy their vessels in foreign countries, a considerable increase is proposed in the construction bounties. For steel or iron vessels the projected bounties are, steamers, 145 francs ($27.30) per gross ton; sailing ships, 95 francs ($18.34) per gross ton. These bounties are reduced annually 3 francs (57.9 cents) for steamers and 2 francs (38.6 cents) for sailing vessels during the first 15 years the law is in operation. After 15 years the bounties will remain fixed at 100 francs ($19.30) for steamers and at 65 francs ($12.55) for sailing vessels. For vessels built of wood the bounties proposed are, ships of 150 tons or more, 40 francs ($7.72) per gross ton; ships of less than 150 tons, 30 francs ($5.79). If any change should be made in a vessel by which the tonnage is increased, the vessel is entitled to the construction bounty for the increased tonnage.

The construction bounty for boilers, engines, etc., is 27.50 francs ($5.31) per 100 kilograms (220.4 pounds), with an annual decrease of 50 centimes (9.65 cents) for 15 years.

In article 8 of the measure exception is made in regard to vessels engaged in a postal service which receives a subvention from the government. For this class of vessels the construction bounty is not increased, being the same as under the present law, 65 francs ($12.55) per ton for the hulls, and 15 francs ($2.90) per 100 kilograms (220.4 pounds) for the machinery, boilers, etc.

The life of the new act is fixed at 20 years from January 1, 1905. The tonnage of new vessels which can enjoy the benefits of the construction bounties is limited for steamers to 50,000 gross tons per year and for sailing vessels to 15,000 gross tons. The construction bounties granted by the new measure are reserved to vessels of which the hulls, machinery, and boilers were built in France; the shipping bounties to vessels which belong to French ports.

All the provisions of the laws of January 30, 1903, and April 7, 1903, which do not conflict with the new measure will remain in force.—*Daily Consular Report.*

GOLD DREDGES.

BY F. F. COLEMAN.

To one who casually examines a gold dredge it seems as though the designing and building of such a craft would be a simple proposition. This was evidently the impression which dominated the minds of those who constructed a large number of the dredges which are in use, and the failure of the designers to appreciate the necessities of the case has cost and is costing large amounts of money to the users. The mistake of the designers was in failing to appreciate the exceptionally arduous character of the work which a gold dredge is called upon to perform, the rapidity with which this work destroys mechanism not especially designed for the conditions, and the rapid reduction in the margin for profits which results from stoppages alone, leaving out of consideration the actual bills for repairs.

Considering the general character of the work, involving as it does the digging and handling of vast quantities of earth and gravel containing at the most but a few cents' worth of gold to the cubic yard, it seems almost a marvel that the industry could have been made to pay at all. As a matter of fact, gold dredging has not only come to be recognized as one of the leading features in gold mining in California and other sections where it has been introduced, but also one of the most profitable. It has even been predicted by men who have been closely in touch with gold-mining interests for years, that within the next ten years gold dredging will double the world's production of the precious metal. While this may be an over-enthusiastic view, there is no doubt that to-day it is the most rapidly growing and most attractive feature in gold mining, and that improvements in the machinery of the gold dredge are of the highest importance.

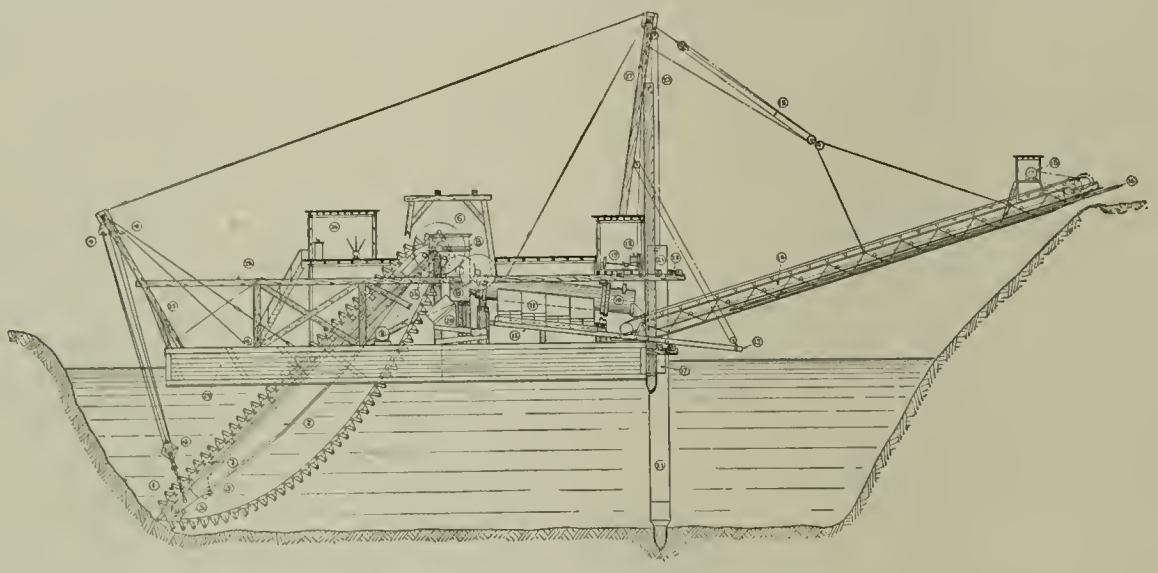


FIG. 1.—SIDE ELEVATION OF A STACKER GOLD DREDGE AT WORK.

The world has many thousands of acres of alluvial lands which contain gold in appreciable quantities. Some of this land is in the beds of streams or lakes, while much of it is high and dry. Some of that which is now being worked by gold dredges is land in cultivation covered with orchards and crops. Even the sites of villages and towns have been invaded by this most modern of gold seekers.

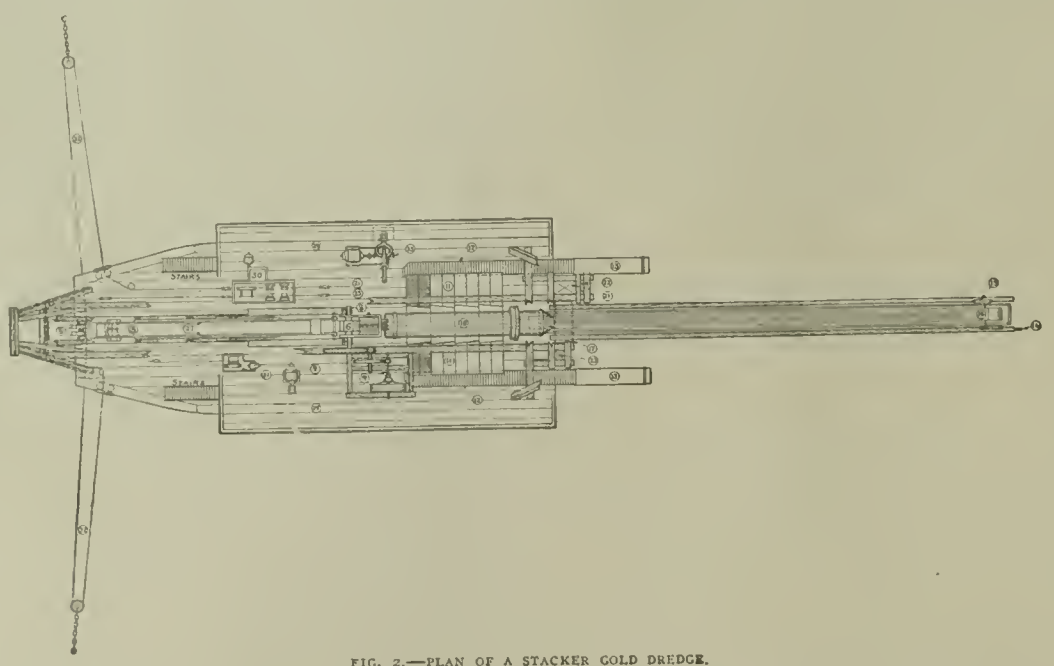


FIG. 2.—PLAN OF A STACKER GOLD DREDGE.

The gold dredge works and travels wherever there is water to be had to float it. This may be in the bed of a stream, a natural lake, or merely in a pool which the dredge itself digs as it advances and fills in again behind it. There must be a sufficient amount of water in addition to that which floats the dredge to

wash out the gold from the earth, but most of this returns to the pool to be used over and over again. In such places the dredge begins its career from a pit dug for it, in which the hull is built.

The dredge itself consists of a broad, rectangular hull of sufficient displacement to carry the machinery, with sometimes a float in addition to support the weight of a long sluice, astern. From the bow to nearly amidship the main hull is cut through in the center, forming a well. Through this well drops the ladder and bucket line which does the digging. This line and ladder is supported amidships by a main shaft which in some designs is also the shaft of the upper tumbler for the endless bucket chain. Its outer end is supported by and raised and lowered from a derrick which straddles the well at the bow and is seated on the hull on either side.

FIG. 3.—STACKER DREDGE READY FOR OPERATION.

The digging line and the gold-saving devices into which the buckets deliver the gravel are the two essential features of a gold dredge. All the other features are incidental. The hull may be handled entirely by lines or it may be provided with spuds; it may carry a complete steam-power outfit aboard—boilers, engines, and all—or it may derive its power from outside sources and use electric motors for every operation aboard. These details have their importance, and no wise person would order a gold dredge without having these points, as well as the more essential ones, determined by experienced and skilled gold-dredger engineers.

There are two general types of gold dredges—the "long sluice" or New Zealand type, and the "stacker" dredge or California type.

The form in which the gold occurs in the land to be worked determines which of these types is to be used. If it is in the common form of rough, irregular pellets, easily washed out and saved without especial care, the long-sluice dredge is the proper one. In this type the gravel from the dredge buckets is dumped into a hopper at a rate of about fifteen buckets per minute. From the hopper it goes into a revolving screen, where the finer material is washed out by means of jets of water sprayed over the mass, while the boulders and coarser matter are discharged overboard through an opening at the side of the boat. Where the ground is free from clay, shaking screens are often used instead of revolving screens.

Under the screen is a short sluice box where most of the gold values are caught. From there the material passes to a steel pump at the end of a short sluice, from which a centrifugal sand pump raises it to the inboard end of the long sluice leading to the dumping place astern. Any values which have escaped the riffles of the short sluice are caught in the long sluice. This form of dredge has the incidental advantage of leaving the ground behind it comparatively level, and with the coarser material deeply buried.

Where the gold is in smaller particles, but still of the character already described, such as that found in the Oroville district in California, the stacker dredge is the form required. Fig. 3 shows one of this type just ready to begin work. Instead of sluices to recover the gold, tables of a special form are used. Before the sand and gravel are passed over the tables, all the boulders are removed by a screen and the stacker takes these and deposits them in great heaps ashore. The stacker is merely a great steel truss boom swung from the stern of the dredge and carrying a conveying belt to dispose of the refuse. Figs. 1 and 2 show the plan and elevation of an Allis-Chalmers stacker dredge.

The gold is found mostly in gravels more or less cemented together. Beds of any thickness up to about 60 feet can be worked. The work of the bucket line is of the most arduous character.

FIG. 4.—ANOTHER STACKER DREDGE.

Good dredging grounds usually contain from 10 to 20 cents' worth of gold to the cubic yard. Those at Oroville are estimated to average about 16 cents. Of this from 75 to 90 percent is recovered.

The nearer a dredge can come to working 24 hours a day for

365 days in the year the more profitable its operations are likely to be. Whether a gold dredge will show a profit or not will depend largely on two conditions: delays, and cost of repairs. Figures gathered by careful observers in various fields show how important these items are. One typical table shows the following percentages of delays from various causes:

CAUSES	PERCENT	CAUSES	PERCENT
Bucket line	23.1	Frictions and winches	2.5
Upper tumbler	16.2	Holidays	1.8
Lower tumbler	8.3	Cleaning up	1.7
High water	15.6	General repairs	1.7
Conveyor	5.3	Electric machinery	1.5
Lines breaking and changing	4.8	Water pump	1.4
Shaking screen	4.5	Ladder and ladder hoist	1.3
Power off	4.5	Bolting	1.3
Oiling	3.8	Stones, rocks and stumps	.7

The parts to be dealt with are few in number. The proposition was therefore the more difficult. It consisted in finding the very best form for every part and employing for each the most durable material. Ease of replacements was as important as added durability. The principal features dealt with in making these improvements are the chain joints, the upper and lower tumblers, and the buckets. A new centrifugal water-lined sand pump has also been provided, which reduces the wear and the power required for operation to the lowest limits.

The weakest points in bucket chains have always been found in the eyes and pins. Bent or broken pins are sources of great loss of time. Subjected as the chains must be to serious wear it becomes necessary at frequent intervals to renew the pins. If the pins are not bent this may be accomplished rapidly with a chain which is otherwise well designed, but with bent pins it becomes a serious matter, and one that costs much time and money. It is not at all uncommon for operators using some makes of chains to have to remove two or three links together and send them to a

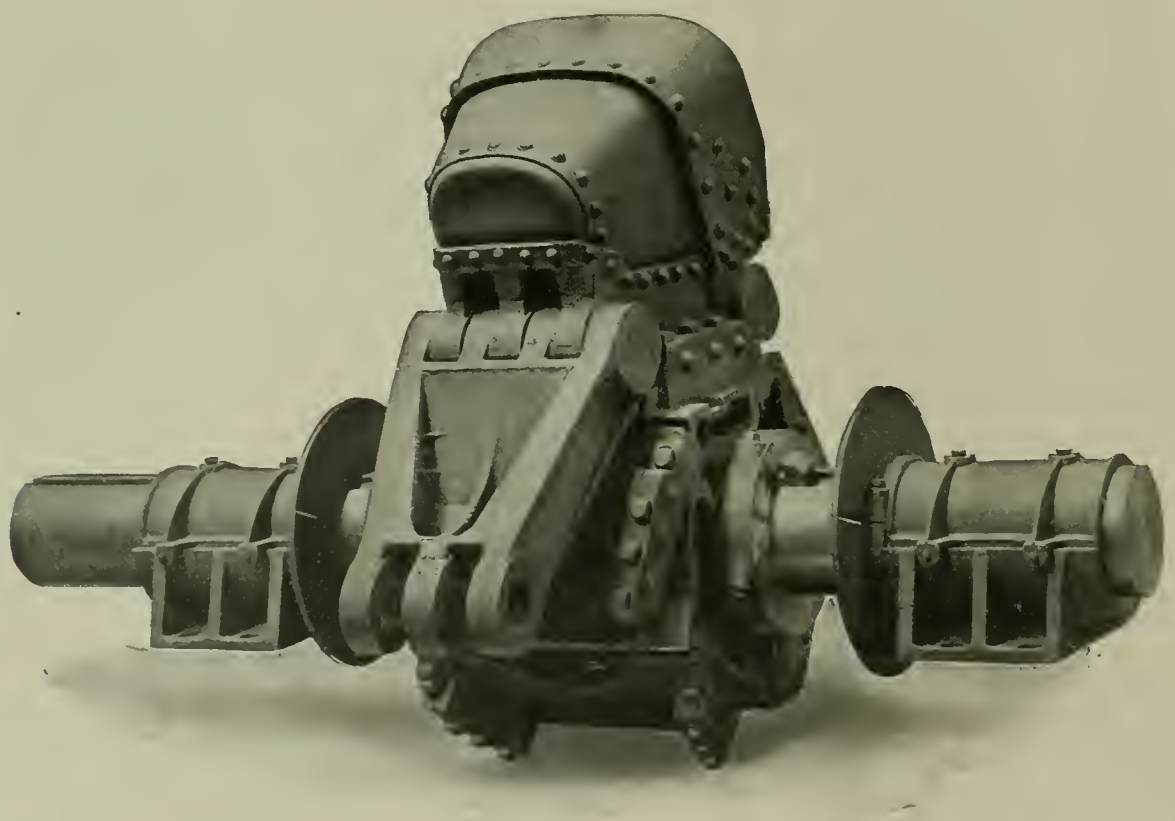


FIG. 5.—OPEN PATTERN DIGGING CHAIN, WEARING PARTS LINED WITH MANGANESE STEEL.

Another typical table shows the cost of repairs compared with other expenses. Its figures cover five different dredges. They cover the cost of operation per cubic yard in cents and fractions of cents:

DREDGES	NO. 1	NO. 2	NO. 3	NO. 4	NO. 5
Repairs	3.80	3.46	3.03	2.97	2.86
Labor	2.05	1.85	1.82	2.33	1.64
Power	1.77	1.15	1.20	1.61	1.06
General	0.73	1.23	0.67	1.28	0.64
Total	8.35	7.69	6.72	8.19	6.20

These figures show that an average of a little more than 43 percent of all expenses goes for repairs. The greater portion of the expense of repairs as well as the bulk of the delays in operation are traceable directly to the bucket line and its adjuncts. It was to meet these conditions and to reduce the two sources of chief expense to the lowest possible limits that the Allis-Chalmers Company set its experts to work.

shop, perhaps miles away, to get the old pins taken out and new ones inserted. The bending of the pins was due to the fact that in nearly all makes of chain there are only two eyes at each end of the links. This makes but two shearing points to a pin, and the pins are frequently broken, while the liability to bending is great. In fact, it is so great, that it is not uncommon to find pins as large as 5 inches in diameter used in some chains.

The Allis-Chalmers chain has seven eyes at each joint. Three are on one end of each link and four on the other end. This form of link gives greater strength and stiffness to a 2-inch pin than a 5-inch pin has in the ordinary chain. The pin has six shearing places where the ordinary make has but two. The eyes are protected from wear by manganese steel bushings, which fit so tightly into the links that they cannot turn. The pins fit loosely in the bushings so that they may turn freely. They are of soft steel and receive the wear. By being allowed to turn freely the wear is distributed evenly so that the pins are not cut into deep grooves as is common, making it difficult to remove them for renewals.

The buckets have also received needed attention in design, to give them the necessary material for wear where they come in contact with the tumblers, and their tips are protected by manganese steel against the wear of digging. They are shaped so as to allow them to take up full loads, and to entirely empty themselves into the screen hopper. They are made watertight to prevent loss of sand and gold through leakage.

Next to the bucket line the part which is ordinarily responsible for the greatest amount of trouble is the upper tumbler.

There are often reasons for using tumblers which differ from one another in the number of their faces and other particulars, but for general purposes a six-sided tumbler is used. This is fitted on a square shaft. The load on the tumbler is constantly changing, often from almost no load to the full capacity of the machine and back again in a moment or two. With round, keyed shafts this is disastrous, batting up the keys and loosening the tumblers. The large flat surfaces of the square shaft have proved much better adapted to the work than any other form. Every portion of the tumbler where wear could come is protected with renewable manganese steel plates. One form of the Allis-Chalmers upper tumbler is shown in Fig. 5.

The lower tumbler is the next most important part. It is designed so that it revolves in bearings which are always submerged in grease. Wedge-shaped rings about the bearings secure it against end play. The bearing faces for the bucket chain are made with large central holes to prevent, as far as possible, the lodging of boulders under the links. These faces and the flanges which keep the chain in place are lined with renewable plates of manganese steel.

In some forms of construction the stacker carries off all the spoil, while in others a sand pump takes up the finer material after the gold is extracted and empties it out on the spoils heap.

The company's new sand pump is novel in that when it is in operation it has a lining of clear water, which effectually prevents the sand held in suspension from cutting the pump. This lining is secured by having the water injected constantly from recesses in the hollow casing, as is shown in Fig. 6. In the long sluice dredge the action of the sand pump serves to thoroughly scour the gold particles and free them from any clay, leaving them bright and ready for amalgamation.

It is strongly recommended that all gold dredges be operated by electricity, even if a steam plant has to be set up ashore for the production of power. There are many good reasons for this recommendation. It saves valuable room on the dredge, where it is useful for gold-saving devices, and decreases the load carried. It also simplifies the question of supplying fuel. The great Oroville district in California has demonstrated the advantages of electric power for this work. Power is supplied there by the Valley Counties Power Company. It is a 3-phase alternating current of 4,000 to 5,000 volts, operating induction motors. The current costs 1½ cents per kilowatt hour.

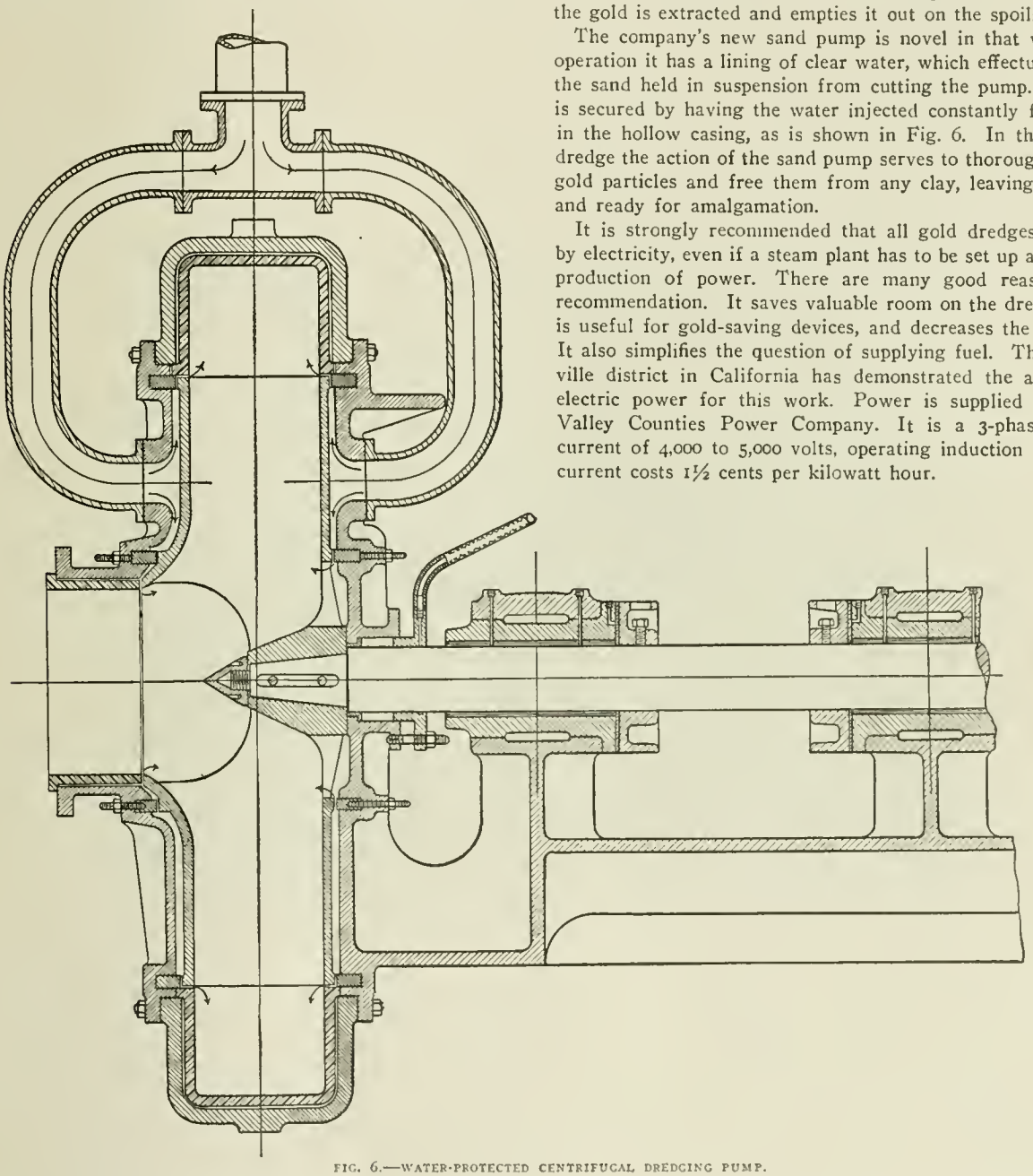
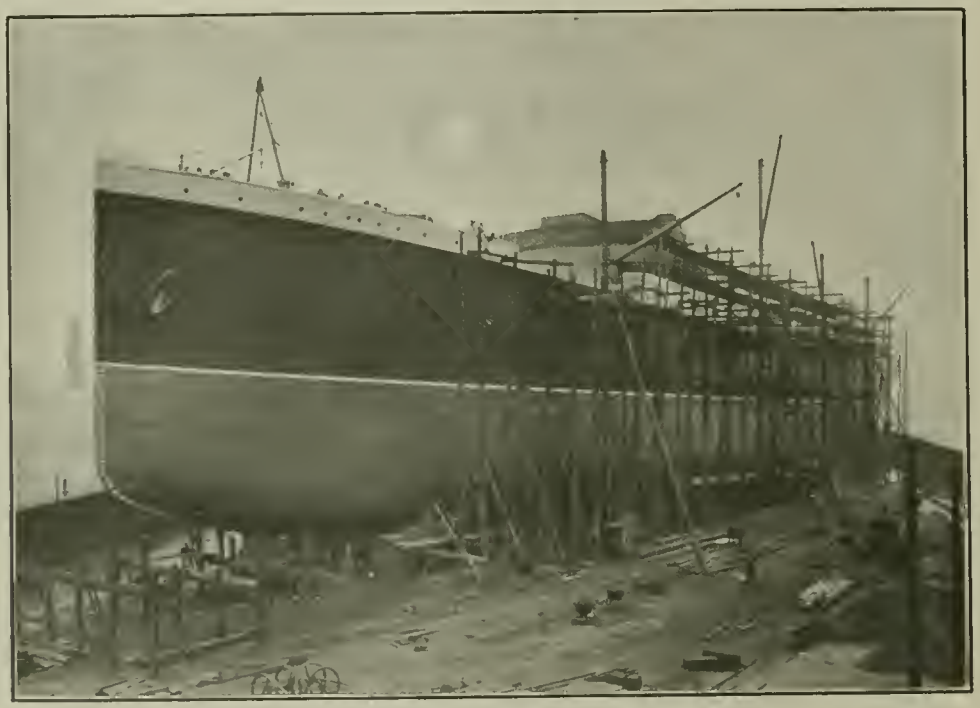


FIG. 6.—WATER-PROTECTED CENTRIFUGAL DREDGING PUMP.

Oroville is the greatest gold-dredge district now being worked. there being about thirty dredges in operation in the district. Other districts where gold dredging is being conducted successfully are Yuba River, Bear River, American River, Calaveras River, Sacramento River, Clear Creek, Trinity River, and Scott River, in California: Foot's Creek, Oregon; Goldfield District, Nevada; Bannock, Montana; McNutt and Brese Basin, Idaho; Elizabethtown, New Mexico; Fraser River, Atlin District, the Upper Yukon, Klondike River, Forty Mile River, British Columbia; Dutch Guiana, and other fields in South America and in New Zealand.

THE LAUNCH OF THE EMPRESS OF BRITAIN.

It is twenty-seven years since the Canadian Pacific Railway was begun. It is twenty years since the last spike was driven into the iron chain which connects the Atlantic and Pacific shores of the Dominion of Canada. At that time it was predicted that the C. P. R. would never earn enough money to pay for the oil to grease its engines, but regardless of prophets of evil it went into ship owning, and established the famous "Empress" line of steamers from Vancouver to the East to feed its railroad. These steamers were designed and built by the Fairfield Shipbuilding and Engineering Company, Glasgow, so when the C. P. R. decided to extend its feeders across the Atlantic, as well as across the Pacific, it was natural that it should turn once more to the Clyde. Moreover, it was at the Fairfield yard that the first of the breed of modern "Atlantic greyhounds" was born. And thus from this famous yard has just been launched one of the most notable additions to the fleets of floating palaces that now do business on the great waters of the North Atlantic. It is a newcomer in the traffic between Britain and Canada, which has so long been in the hands of a very limited number of British lines, but the trade is broadening and there should be room for all.



THE EMPRESS OF BRITAIN ON THE WAYS.

(Photograph, Allan McPherson.)

The twin screw steamer *Empress of Britain,* which the Fairfield Company launched, November 11, 1905, is the first of two sister ships they are building for the Atlantic mail and passenger service of the Canadian Pacific. The second, the *Empress of Ireland,* is well forward, and will be launched in January, 1906. The *Empress of Britain* is not the longest vessel which has been built by the Fairfield Company, but she is the heaviest. Their longest were the Cunard liners *Campania* and *Lucania,* launched in 1893, which are 601 feet in length, while the Canadian Pacific boats are 569 feet. The Cunarders are narrower, being 65 feet 2 inches compared with 65 feet 6 inches, and also less deep—37 feet 8 inches as compared with 40 feet to upper deck. The Canadian Pacific boats are of 14,500 tons gross, while the Cunarders are 12,952 tons. The *Empress of Britain,* which displaces 20,000 tons, is built to Lloyd's three deck and shelter deck 100 A1 class, with forecastle and long bridge. A cellular, double bottom is fitted the full length of the ship, and the vessel is subdivided into separate compartments by watertight bulkheads, which are constructed to obtain every security. There are nine watertight bulkheads, all extending to the level of the upper deck, built in accordance with the recommendations of the bulkhead committee. With any two compartments filled with water the ship would still remain afloat. All the decks are plated and sheathed, with teak where exposed, and with yellow pine where under cover. There are in all eight decks. On the boat deck at the fore end there is a spacious deckhouse for the accommodation of the captain and officers, with chart house and wheel house. In front of the wheel house, for the full width of the ship, is a space reserved for the navigation of the ship, and aft of the wheel house, divided from the officers' quarters by a barrier rail, is a fireman's airing space, with shelter in case of bad weather, and in direct communication with the boiler rooms.

In working out the design of this ship full consideration has been given to the experience of latest vessels built for the Atlantic trade in order that the new vessels shall embody everything that can be conceived for the safety and comfort of the traveling public. The design is by Dr. Elgar, the company's naval architect, and the building of the vessels has been under the direction of Mr. Arthur Piers, the manager of the Canadian Pacific's steamship department, assisted by Captain Mowatt, their marine superintendent at Liverpool.

Special consideration has been given to ventilation, and a thermotank system on the Stewart principle has been adopted as the most efficient method. There are 48 thermotanks placed to supply either heated or cold air, and to extract foul air from every corner of the ship, and they can be worked either separately or collectively so that any temperature can be maintained. Electric fans are also fitted in the public rooms and galleys. The sanitary arrangements have also received careful consideration, and a large number of lavatories, bath rooms, wash basins, etc., complete with hot and cold water and foot baths, are arranged at intervals on the various decks. The floors are laid with interlocking rubber tiles. There is a complete installation of electric light with three independent generating engines and dynamos, providing power for lights in all compartments. There are also a hospital, printing room, dispensary, hairdresser's shops, mail

rooms, and specie room, and wireless telegraphy with a suitable house fitted out for the receipt and dispatch of messages.

There are twelve cargo winches and two boat hoisting winches, and the driving gear is so arranged that no noise or vibration is created when working the cargo. The refrigerating installation is of adequate proportions for the preservation of general provisions, meat, vegetables, etc., and the making of ice. There are three large and one small refrigerating machines. The three large machines are for cooling the three large cargo cold chambers, the insulation and brine grids being so arranged that the temperature may be varied to suit the carriage of frozen meats, apples, etc. The small machine is for cooling the provision chambers on the upper deck, and the cold larder in the main galley. It can also make thirty blocks of ice, each weighing 18 pounds, in eight hours.

The steering gear is of the latest type, with telemotor, and there is also a reserve steam steering gear which may be readily put into operation if required. The gear is placed right aft on the orlop deck in a watertight compartment below the level of the waterline, and is coupled direct to the rudder post. It is actuated from the wheel house and also from the promenade deck aft. There is an indicator and a rudder tell-tale in the wheel house.

A powerful windlass of the direct-acting type is placed on the shelter deck, and a capstan driven off the windlass is fitted on the forecastle deck above. Two warping capstans at the aft end of the shelter deck are driven by horizontal steam engines, with slow and quick speeds.

A topgallant forecastle towers at a great height above the waterline, and will increase to a very large extent the weather qualities of the vessel. The forecastle on the upper deck is for the third-class passengers, that on the shelter deck for the crew.

The machinery consists of two sets of quadruple expansion engines, each with four cylinders working on four cranks, balanced on the Yarrow and Schlick system to reduce vibration to a minimum. The high-pressure and the first intermediate-pressure cylinders are fitted with piston valves, and the second intermediate and low-pressure cylinders with ordinary flat slide valves; and all are worked by link motion valve gear. The reversing gear is of the "all-round" type, controlled by a double cylinder steam engine. The crank shafts are in four sections, each section being built up, and like the thrust, tunnel, and propeller shafts, are of forged mild steel. The propellers have each four blades of manganese bronze, with bosses of cast steel.

Water is circulated through the condensers by two large centrifugal pumps, each worked by an independent engine. Both circulating pumps are connected to large valves leading to the bilges, and can be utilized for pumping out the engine room. The air pumps are independent of the main engines, being worked by separate steam engines. The engine room is fitted with two evaporators working in combination with two distillers for supplying fresh water to the ship and to the boilers, and with large feed filters, feed heaters and all necessary fittings to insure economy of working. A large installation of donkey pumps is provided for all requirements.

The boilers are nine in number, in two watertight compartments, with a large coal bunker between. There are six double-ended and three single-ended boilers of the ordinary multitubular type, arranged to work with Howden's forced draught. They are constructed entirely of steel and adapted for a working pressure of 220 pounds per square inch. The double-ended boilers have each eight furnaces, and the single-ended four furnaces—a total of 60. The products of combustion are led into two funnels.

TAKING THE WATER, SHOWING SMOKE FROM BURNING TALLOW.
(Photograph, Allan McPherson.)

Accommodation has been provided for 310 first-class, 470 second-class and 500 third-class passengers, all on and above the main deck, and for 270 steerage passengers on the lower deck forward. The remainder of the lower deck, with the whole of the orlop deck and hold, is cargo space, and two of the 'tween deck holds will be insulated for carrying frozen meats.

The lower and upper promenade decks amidships are entirely devoted to the accommodation of first-saloon passengers. The staterooms for one, two or three persons are large, airy rooms with comfortable couches, combination double-folding washstands and writing tables, wardrobe with beveled pier glass, electric light, electric bells, and large, square opening windows with ornametal glass shutters. There are several family or

private cabins, built in pairs, with a door in the dividing bulkhead, so that any two of the rooms can be allotted to a party of two, four, or six persons.

On the upper promenade deck, amidships, the saloon entrance has a broad, handsome staircase leading to the lower promenade deck, and from there to the shelter deck. This staircase is paneled in light colored, polished teak, and lighted by a large dome. Abaft, on the upper promenade deck, is the music room, the ceiling and walls of which are of satinwood, with crossed bands of tulip wood. The library is a comfortable room, framed in mahogany with amboyna panels, with bookcase and other furniture to match. The café is immediately below the music room, and within easy reach of the first-class dining saloon. The paneling is framed in Italian walnut, waxed, with tapestry panels, and the floor is laid with rubber tiles. Aft of the café is a commodious smoking room, with large, square windows round the side, and a rectangular well over with ornamental fret, and provision for ventilation. The floor is laid with rubber tiles, and the walls are framed in slightly fumed oak with hammered copper panels. A clear promenade of 10 feet 6 inches wide for the first-class passengers, with recesses in the deckhouse forming sheltered corners, is on each side of the upper and lower promenade decks amidships. The lower promenade deck extends right aft to the stern of the ship, which is a new feature, and forms a fine open promenade for both first- and second-class passengers.

The first-class dining saloon is a splendid apartment, measuring 58 feet by 62 feet wide, and can dine the whole complement of saloon passengers at one sitting. In the center are four large dining tables running fore and aft, and at the sides, in alcoves, there is an arrangement of dining tables, each for five persons, the five seats forming a semi-circle round the tables. In each alcove are two large windows with ornamental shutters, which, together with a large oval dome overhead, afford light to the saloon. The paneling is in mahogany enameled white, with carving in old gold, and the furniture is upholstered in crimson leather. At the fore end is an upright grand piano and at the after end a large sideboard. The pantry is at the after end of the saloon, from which it is divided by a serving passage. This pantry, together with the pantry for second-class, and the various galleys, bakehouses, baker's shop, larders, etc., form one large kitchen, equipped with the best cooking apparatus, electric hoists and ventilating apparatus.

The second-class accommodation is on the shelter deck, dining saloon, social hall, and smoking room, with stairways leading to the upper and main decks. The dining saloon is capable of seating about 300 persons, and is fitted with alcoves at the side, like the first-class saloon. The walls are paneled in mahogany, with furniture to match. The social hall, or music room, is framed in light oak with light oak panels below and bird's-eye maple panels above. The second promenade deck is sheltered by the lower promenade deck, and on it the second-class smoking room is arranged with cosy corners and armchairs. The upper deck has two side fore and aft passageways, the one on the port side being for the ship's company, ship's provisions, butcher's shop, etc., and the working of the ship generally, and that on the starboard side is for first- and second-class passengers. A nursery is also provided for children. The majority of the second-class staterooms are on the main deck aft, and are airy rooms for two, three or four persons, fitted up somewhat similar to the first-class staterooms.

THE NEW SHIP ALONGSIDE DOCK FOR FITTING OUT.
(Photograph, Allan McPherson.)

The third-class passengers are on the main deck forward in cabins accommodating from two to six persons, and there is a large dining saloon capable of dining over 300 persons. From stairways in each compartment the passengers can reach the promenade on the upper deck, which is covered, or the open promenade on the shelter deck. On the upper deck there is a smoking room and a ladies' room for the third-class.

At the forward part of the main deck and on the lower deck, provision is made for steerage passengers in open berths, with dining accommodation and other conveniences.

Civil Service examinations are announced for January 3 and 4, 1906, to fill vacancies in the position of local inspector of hulls of steam vessels, at $1,500 per annum. Age limit, twenty-five to fifty-five years. Applicants should apply to the Civil Service Commission, Washington, for forms 1,087 and 1,405.

Examination is announced for January 3 and 4 for vacancies in the position of assistant inspector for boilers and steam vessels, at $1,800 per annum. Age limit, twenty-five to fifty-five. Applicants should apply for forms 1,087 and 1,405.

MARINE APPLICATIONS OF THE CURTIS STEAM TURBINE.*

BY CHAS. G. CURTIS.

The first vessel to be propelled by steam turbines of this type, and the first vessel of any kind to be fitted with twin shafts and screws and twin turbines independently controllable and reversible, was the yacht *Revolution*, built in 1902. This yacht had a length of 140 feet on the waterline, beam of about 17 feet, a draught of 7 feet and a displacement of about 200 tons, and was provided with two independent turbines of about 1,200 horsepower each, turning outward and designed to run between 650 and 750 revolutions under full speed conditions. The turbine casing, including the reversing mechanism, was only 5 feet 10 inches in diameter and about 4 feet long. The turbines were not designed to show any remarkable economy, but were expected to consume about the same amount of steam as an ordinary triple expansion engine under the usual conditions of service. This yacht was put into commission in the spring of 1902, and was kept in commission and used for exhibition purposes continually, with the exception of two months during one winter, for a period of a year and a half.

The practical operation of the turbines was in every respect most satisfactory and convincing, neither one ever having required any repairs of any kind, and the steam consumption was shown by torsion shaft test to be substantially equivalent to that of the ordinary triple expansion engine under average working conditions. The boat, however, failed to develop the speed anticipated, and it was a long time before we could find out why this was so. The impression seems to have got abroad among marine engineers that the failure of this boat to show a speed consistent with the high power provided was in the main due to a failure of the turbines to develop the necessary horsepower. Such was not the fact. One of the turbines, when driving the screw in the ordinary way, was subjected to a very careful torsion shaft test by Prof. James E. Denton, who, with Prof. Webb, devised and worked out an ingenious and accurate method of measuring the angle of twist of a specially calibrated length of torsion shaft introduced into the line shaft for this purpose. The tests showed that the turbines developed the full power expected, and that the steam consumption was about 17½ pounds per indicated horsepower. The results are given in the following table:

POWER AND ECONOMY OF ONE TURBINE.

Number of Steam Passages in Use.	Revolutions per Minute.	Brake Horsepower or Horsepower Delivered to Propeller.	Indicated Horsepower of Equivalent Piston Engine.	Dry Steam per Hour Indicated Horsepower of Equivalent Piston Engine.
4	748.0	1,096.0	1,267.0	17.46
3	672.8	761.6	898.7	18.14
2	596.6	467.1	572.0	19.12
1	452.5	192.3	269.5	21.34
1 throttled.	265.3	95.7	146.2	24.67

The failure to get the expected speed, viz., 21 to 21½ knots, under conditions where the boat actually showed only about 18 knots, furnishes another illustration of how easy it is to "fall down" in an engineering matter of this kind, even when the best knowledge and talent are availed of. In order to insure success we not only had the vessel designed by a well known firm of yacht designers and builders who had previously built a yacht which was and still is the fastest yacht in this country, but we had the yacht's model tested in the government testing tank in Washington, and the screws were designed by a very distinguished authority in this country. Several sets of screws were built for the boat, the last set having a diameter of 4 feet and a pitch of 4 feet and having thin blades of well known form. From what is now known of the action of propellers of this character, and from the fact that the turbines did develop the power expected, we have been led to conclude that the trouble with the *Revolution* was in her model, which in the afterbody is very bad, her floor not being drawn out aft far enough. This view is confirmed by the best marine architects whom we have consulted about the matter and who have observed the wave action of the boat, which is very excessive, even at a speed of only 18 knots.

The reversing and maneuvering capacity of the *Revolution* was even better than anticipated, and was very satisfactory. In a maneuvering test made by a board of the Navy Department it was found that when going ahead at full speed (about 18 knots) the boat was brought to a standstill in the water in 32 seconds after the engine room telegraphs were thrown over. The boat was used extensively about New York harbor for a year and a half, and her reversing power was called into play to the utmost very frequently, but it never failed to respond with the necessary power, and during the whole period of her use as a "demonstration" no trouble of any kind whatever was had with either of the two turbines.

Some time ago the Fore River Shipbuilding Company, of Quincy, Massachusetts, at the instance of its president, Admiral Bowles, and after an investigation into the comparative merits of the two types of steam turbines available for the purpose, entered into contracts for the construction of two large vessels to be equipped with twin independent Curtis turbines, which vessels, together with the turbines, the company is now building. One of these is the United States scout cruiser *Salem* and the other is the Southern Pacific steamer *Creole*, particulars of which are as follows:

	Salem.	*Creole.*
L. W. L.	420 ft. 0 inches	415 ft. 8 inches
Breadth	46 " 8 "	53 " 0 "
Draught	16 " 9½ "	25 " 0 "
Displacement	3,750 tons	10,160 tons
Horsepower	16,000	8,000
Speed	24 knots	16 knots

In both vessels there are two shafts and two screws with complete independent turbines on each shaft. In the case of the *Salem* the proposed revolutions of the screw at 24 knots are 350; in the case of the *Creole* somewhere between 225 and 275. The space occupied by the turbines fore and aft (including the reversing mechanism) is only about half that occupied by the equivalent triple or quadruple expansion four-cylinder engine, and the weight is considerably less. In the case of the *Creole* the weight of the two turbines is, roughly speaking, about half of that of the equivalent quadruple expansion engine. The total saving in weight of the engines, shafting, propellers, etc., is very considerable. Each turbine is in the form of a drum-shaped shell, built up in sections, having an outside diameter of about 11 feet and an overall length of about 14 feet. Each turbine comprises 7 stages for going ahead and two stages for reversing. There is no end thrust due to the pressure of the steam in the turbine itself and the propeller thrust is taken up by the ordinary thrust block external to the turbine.

During the past summer the Vulcan Shipbuilding Company, of Germany, completed a turbine vessel called the *Kaiser*, which is fitted with two shafts and two independent turbines of this type. The turbines were built for the Vulcan Works by the Allgemeine Elektricitäts Gesellshaft, of Berlin, who are licensees under the Curtis Turbine patents, and were designed by and built under the direction of Mr. O. Lasche, the technical director of the turbine works of the Allgemeine Company. The performance of these turbines and of the vessel on her trial trip was admirable, and reflects great credit upon Mr. Lasche and his associates, and also the designing engineers of the Vulcan Works, who assumed the responsibility of getting efficient screw action under the unusual conditions. The guarantees were intended to represent the performance of a first class, 4-cylinder, triple expansion engine, and the ordinary slow-turning screws, which necessarily have a somewhat higher efficiency than the comparatively high-revolution

*Read at the thirteenth general meeting of the Society of Naval Architects and Marine Engineers, November 17, 1905.

screws requisite for turbine propulsion. The actual figures guaranteed were a speed of 19½ knots, and a consumption during a 6-hour run of not over 4,700 kgs. of coal per hour, including all auxiliaries. Progressive speed trials were had up to 20.46 knots, the propellers turning at 555 revolutions per minute. During a 6-hour run 20 knots was averaged on 4,060 kgs. of coal per hour. We have not yet ascertained positively what the horsepower developed was, but we understand that the shaft horsepower was measured by the use of a torsion shaft, and we understand on good authority that the indicated horsepower of the engines for the ship at 20 knots is estimated at 5,700. Whether this is derived from the shaft horsepower measurement or confirmed by the shaft horsepower measurement we do not as yet know. But if this figure—5,700 indicated horsepower—sent us is correct, the coal works out at 1.56 pounds per indicated horsepower, including all auxiliaries. The coal result is, if anything, better than these figures show, for during two hours the safety valves were blowing and the steam by-passing to the condensers. On a basis of the cube of the speeds the horsepower at 20 knots would be 8 percent greater than that at 19½ knots, and as the coal consumed at 20 knots was only 86.4 percent of that guaranteed for 19½ knots, it would appear that at a speed of 19½ knots the coal consumption would be just 80 percent of the amount guaranteed.

The dimensions of the vessel are as follows: Waterline length, 310 feet; beam, 38.2 feet; draught on trial trip, 9.74 feet; displacement, 1,890 tons of 2,240 pounds.

In order to test the maneuvering and backing qualities of the turbines, which were entirely independent, another engine-driven vessel belonging to the same line (the Hamburg Line) was brought to the spot for comparison, and it was found that the turbine ship was brought to a stop in the water in slightly less time than that occupied by the engine-driven ship. I am informed that during the trials the turbines gave no trouble, and their practical operation was entirely satisfactory.

Each turbine is built in the form of a drum-shaped shell built in sections, the shell having a length of about 11½ feet and an outside diameter of a little over 8½ feet, the reversing apparatus being all contained within the same shell. The weight allowed for each turbine was 70 tons, and the actual weight was 57 tons.

A very remarkable feature of the result seems to be the screw performance at the unusually high revolutions. Three or four pairs of screws were tried before the desired result was obtained, the turbines originally having been intended to run at 600 revolutions. The characteristics of the screw we have not as yet ascertained and cannot, therefore, state them, but it would seem from the excellent performance of the propelling machinery as a whole that the screws must have been surprisingly efficient in their action, considering the fineness of pitch involved.

Shop tests of the turbine to ascertain their horsepower economy had previously been conducted, the power developed being measured by a disk water brake with the following results: with a boiler pressure of 12 atmospheres or 190 pounds abs. with dry steam and a vacuum of 28 inches the steam consumption per brake horsepower was 12.76 pounds at 600 revolutions and about 13.7 pounds at 500 revolutions.

Iron- and Steel-Hull Steam Vessels of the United States is the title of a very interesting and historically valuable monograph by J. H. Morrison which has been running through the columns of the *Scientific American Supplement*. The series carries the development of the art from the early experimental period down to the present time, citing numerous notable examples of ships marking the different milestones of progress. A number of illustrations of the earlier constructions may be compared with those most up-to-date, and the great strides in the art readily followed. Among the ships noticed might be mentioned the old *Michigan*, now the *Wolverine*, which was the first iron warship constructed in any country. She was built at Pittsburg in 1842, and then shipped in sections to Lake Erie.

Winter Navigation of the St. Lawrence.

The Dominion government is about to test the feasibility of keeping the St. Lawrence river open to navigation during the winter months by the help of an ice breaker, such as has been successfully employed by the Russian government in the Baltic Sea. A conference has just been had between the Minister of Marine and the officers of the Dominion Coal Company, to whom the task has been assigned of sending, in December, from Sydney to Montreal, a coal-laden steamer, accompanied by the ice breaker *Champlain* from the vicinage of Quebec, where she is now waiting for the freezing of the river to make this trial. It is believed that there will be no difficulty in keeping the St. Lawrence open as far as Three Rivers at least, for a period in the early winter and spring, but much doubt is expressed regarding the part beyond here. The lake St. Peter, a few miles above here, *en route* to Montreal, will probably present the greatest obstacles, and it is doubted whether that portion of the river can ever be kept open. Should the experiments confirm this doubt the port of Three Rivers will naturally gain considerably in importance as a shipping center. The effort to escape from

ICEBREAKER MONTCALM, HAULED OUT FOR REPAIRS.

the present obligation of using Portland, Me., as port for the transatlantic shipping of this region of the Dominion is, of course a prominent factor in the ice-breaker project.—*Daily Consular Report*, December, 1904.

For the purpose of coping with the difficulties involved, there was launched from the yard of Messrs. Napier & Miller, Ltd., Yoker, the twin-screw ice breaker *Montcalm*, built for the Canadian government for work on the St. Lawrence, to the order of Messrs. Fleming & Ferguson, Ltd., Paisley, who have supplied the machinery. The principal dimensions are: length, 245 feet; breadth, 40 feet 6 inches; depth, 18 feet, with a gross tonnage of about 1,350 tons. The vessel has been built under Lloyd's special survey, and is designed for ice-breaking purposes, being greatly strengthened in order to resist the enormous pressure to which she will be subjected. The contract for this vessel was placed in July, 1904, and the building occupied a remarkably short space of time.

The *Montcalm* broke her propellers in ice ten feet thick, fifteen miles above Quebec, and was hauled out by Geo. T. Davie & Sons, Levis, Quebec, for repairs in weather "twenty below." The experiment is to be continued this winter, and better success is anticipated.

MOTOR BOATS, VII.

BY DR. W. F. DURAND.

ABOVE-WATER FORM.

The form of the boat above the waterline is to be determined by reference to the following four main considerations:

(1) Utility.
(2) Safety.
(3) Appearance.
(4) Air resistance.

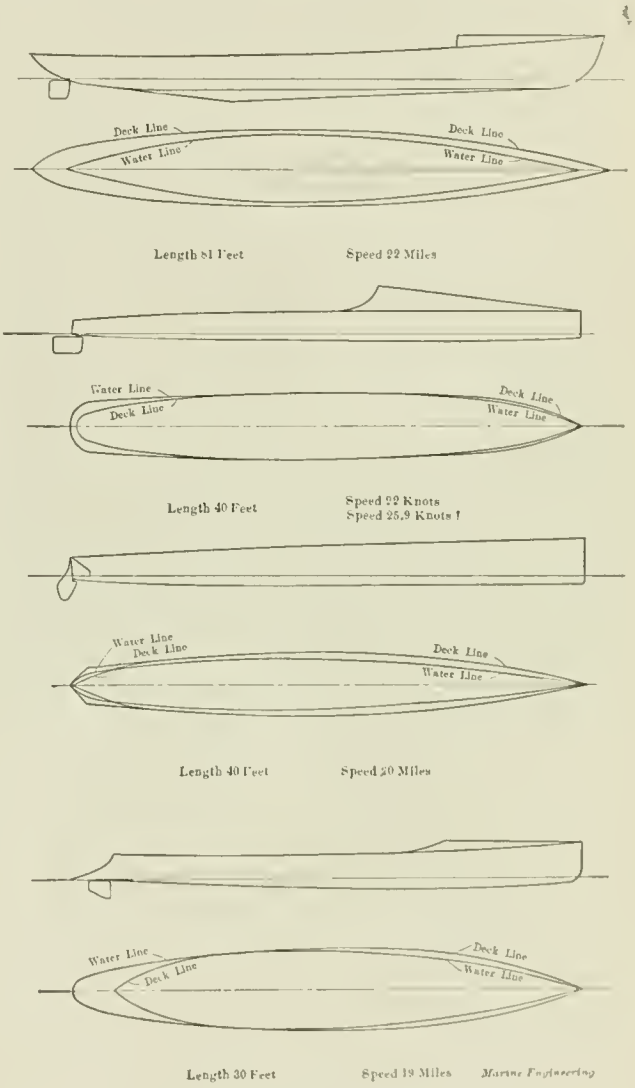
The relative importance of these will naturally vary with the details of the case in hand. Where the highest possible speeds are desired the question of air resistance will become of importance, and may lead to a type of form in which all other considerations are sacrificed in varying degrees. It will be convenient to take this extreme type of form as a starting point, and we shall therefore consider first the problem of air resistance and the means which may be taken in order to reduce to a minimum its influence on the speed of the boat.

Because air resistance is comparatively small, especially at low speeds, it should not be assumed that it is by any means negligible Indeed when the highest attainable speeds are aimed at no item can be neglected, due attention to which might in any way help forward the main purpose in view. Air resistance becomes of the more importance because of the fact of cross and head winds which must be encountered, and the added relative velocity which will exist in the latter case. Thus a fast motor boat going at the rate of 20 miles per hour in still air meets an air resistance due to this speed. A moderate headwind of 10 to 15 miles per hour will raise the relative speed to 30 or 35 miles and will easily increase the air resistance to two or three times its first value. So much the more serious will be a headwind of 20 or 30 miles per hour, raising the relative velocity to 40 or 50 miles and increasing the air resistance four to six fold at the same speed through the water. With such a rapidly increasing fraction of the total power absorbed in overcoming air resistance, it is clear that any such conditions of adverse wind will seriously lower the highest attainable speeds, and that such scaling down will be more pronounced as the above-water form departs farther from the conditions for low air resistance.

As the first principle to be held in mind it may be stated that forms favorable with respect to air resistance should be as nearly as possible smooth and continuous in curvature, and especially with the minimum amount of abrupt change of form or flat head surface. Such features as a standing awning or a projecting pilot house should not be tolerated for a moment if air resistance is to be reduced to the lowest terms. In short, it should be remembered that the upper body of the boat is passing through a fluid (air) no less real than that through which the lower body is passing, and no less capable of occasioning a resistance, even though it is usually much less in amount. It follows that the form most suitable for low air resistance must be similar in general character to that most suitable for low water resistance; or, in other words, that the form of upper body should be not far different from that of lower body. This, of course, is impracticable in full measure, but we may with advantage remember that as the upper body is made to resemble the lower body in general form and character, so will the air resistance be decreased, and by so much less will the attainable speeds be cut down by this cause. It will thus be of interest to note the form of upper body which, in accord with these principles, would insure minimum air resistance.

Such a form would show in general a turtleback type of construction, covered completely over and sloping down to a junction with the under-water body as nearly as possible at the water surface. In side elevation it would show an arched form rising from near the water surface at the bow to a maximum height somewhat forward of amidships and sloping down gradually to the water surface at the stern. Similarly, in transverse section, the form will resemble an arch rising from the water surface at each side to a maximum height amidships, the general proportions of such arch being at the same time adjusted to the general character of the fore-and-aft form. Optical means for enabling the steersman to find his way, as well as general questions of light and ventilation, are, of course, matters which need not be considered in connection with such a form, which is intended only as an ideal toward which actual construction may approach as the need of reducing air resistance becomes of higher importance.

Habitability and general utility with such small boats require an open cockpit as well as some freeboard for safety, while for rough water conditions the forward deck cannot be made to



MOTOR BOATS, ILLUSTRATING TURTLE-BACK CONSTRUCTION, STRAIGHT SHEER LINES, AND VARIOUS FORMS OF STERN.

slope down quite to the smooth water line of flotation at the bow. It is of interest to note, however, that the turtleback form, especially forward, has met with favor by many designers, and that in skilled hands it may be treated in such manner as to yield a form not displeasing to the eye, and unquestionably contributing largely to the reduction of air resistance at high speeds.

Turning now to a more general census of the factors which determine the above-water form, they may be specified as follows:

(1) Sheer line and freeboard.
(2) Waterline.
(3) Form of bow.
(4) Form of stern.
(5) Arrangement of cockpit, deck erections, etc.

There is much diversity of practice in connection with the item of sheer. In general, however, the present fashion with motor boat designers seems to lead to less sheer than was formerly in vogue, especially for small craft of 20 feet or thereabouts in length. With racing craft, or boats of the highest attainable speed, the upper line shows often but slight sheer at the rail, and at a distance, taking the rise of the forward deck amidships, the central longitudinal line shows often a slope downward and forward, as in the turtleback type elsewhere referred to. Sheer has its uses in connection with safety and dryness forward, and unquestionably lends a jaunty and pleasing air to boats of moderate size, and with such other proportions and characteristics of form as show them to be intended for moderate speed. On the other hand, the long, slender form of the racer agrees well with the slightly curved rail line and with the forward and downward slope of the central fore-and-aft line, as noted above.

Freeboard as a factor in the above-water form bears important relations to both safety and air resistance, with perhaps more secondary relations to general utility and appearance. Insufficient freeboard may give rise to two dangers—the shipping of water in moderately rough weather and a reduced range of stability. Each of these may involve some element of danger for the boat, and having due regard to safety in these respects, a reasonable freeboard should be provided. What is reasonable in any given case must be determined by the designer in view of all circumstances of the case, and for the purposes of the present discussion it will be sufficient to simply note the principle that in general increase of freeboard up to some value considerably beyond the usual proportions will make for increased stability range, and for added safety in this particular. Increased freeboard means however, increased air resistance, especially in a headwind; and here, as at all other points, we meet the necessity of compromise and adjustment between mutually conflicting requirements.

Regarding the waterline or plan view, the form and proportions of this feature will depend primarily on the under-water body, as considered in the preceding chapter, and this item will require no further consideration at the present point.

Regarding the form of the bow, some designers are disposed to flare out the sections from the water surface upward at and near the bow, thus rapidly increasing the bearing as the bow descends into the water or dives into a wave. This will have the effect of reducing somewhat the extent of pitching in a head sea, and may thus contribute to safety and comfort. As a rule, however, having in view the average weather in which such boats are expected to be used, most designers are content with a nearly vertical side at and near the bow, depending on the freeboard and other general proportions to give the needful steadiness relative to pitching, and the general safety relative to the action of the waves.

The form of the cutwater has been noted in the preceding chapter. General practice leans toward a cutwater raking somewhat forward and with a rounded curve under the forefoot. The tendency of these characteristics in excess will be to shorten the waterline length when running at high speeds, as already noted. So far as this consideration is concerned, therefore, the forward rake should be very nearly suppressed and the round under the forefoot should be kept at least under water when at full speed.

Coming next to the stern, we meet perhaps the most difficult of all features of boat design, especially with reference to considerations of general appearance. The character of the torpedo-boat stern has been already referred to in connection with the discussion of the under-water body. There is no question of the difficulty of the problem which this stern has presented to designers with respect to the combination of the typical form below water with pleasing form characteristics above water. In the earliest sterns of this type the above-water form was usually some close approximation to the older and familiar round or raking stern, joined by an abrupt knuckle to the flat floor of the under-water body. These combinations were rarely graceful or pleasing, representing as they did the attempted combination of two entirely distinct types of form, neither part properly adapted to the other. In later and more satisfactory forms the old and conventional stern has been left aside and new above-water forms have been developed in conformity with the general conditions of boat design and with the type of under-water body with which they are to be joined. In certain varieties of this type the member corresponding most nearly to a sternpost is raked or curved forward, while the water-plane and horizontal sections cut by all parallel planes are brought to a point either sharp or somewhat rounded. The chief disadvantage of this variety is perhaps that in its more narrowly pointed extreme it is somewhat less well adapted to a wide and roomy stern cockpit, or in any event such pit cannot extend quite as far aft as in forms which are broadly rounded or flat across the after extremity. Such rounded or flat varieties, with more or less pronounced tumble home, and in elevation showing a forward rake to the after boundary line, represent still other solutions of the same general problem; and all varieties here noted, with intermediate gradations, are to be found in the practice of the day. Reference may also be made to the cuts accompanying the preceding and present chapters for illustrations of these forms of above-water body.

Comparing for a moment the torpedo-boat stern with the older or ship form with deadwood and fine waterlines aft, it will be seen that the natural widening of the above-water body which the torpedo-boat stern permits gives usually more width and roominess on about the same proportions, and is thus favorable to general utility and comfort. With the rounded or flattened after extremity this width is especially pronounced, and is the feature especially commending such variety of form for various classes of boats. Naturally, however, excessive width and roominess must go with moderate speed, and *vice versa* the highest speeds can be expected only with such forms as involve some sacrifice of width and general carrying capacity. Utility, further, is a quality which must be interpreted in accordance with the nature of the case, and it is not until it is thus interpreted and expressed in engineering terms that it becomes a matter capable of direct study and definite determination.

Again, as regards appearance, it must be remembered that this is largely a matter of taste and convention, and taste is largely a matter of education. When the torpedo-boat stern was first introduced it was generally considered as decidedly ugly and lacking in all those qualities of grace and beauty which may be embodied in the older and conventional form. To-day forms of torpedo-boat stern are worked out in such a manner as to appear pleasing to the eye and generally satisfying to our sense of the beautiful. This is due to two chief causes: (1) Since its first introduction we have become accustomed to the general characteristics of this form of stern and to its peculiarities, as distinguished from the older form, and have thus become educated in the toleration and acceptance of features which, with our conventions and ideas of fifteen years ago, seemed crude and displeasing. (2) The problem has received a vast deal of attention and study on the part of naval architects and designers. and forms and proportions have been evolved which are unquestionably more pleasing than those through which this form of stern first made its appearance as a factor in small boat design.

Again, it must be accepted as a principle of all such classes of design that in a boat intended for the highest speed, considerations of utility and especially of appearance must be made subordinate to those qualities having primary relation to the requirement of speed. It must not be concluded, however, that a fast boat is necessarily ugly. Within the limitations imposed by the requirement of high speed, the skilful designer will be able to combine his elements in such manner as to be at least not displeasing to the eye while at the same time fulfilling the technical requirements for maximum speed.

So far as considerations of safety are concerned, the torpedo-boat stern suffers somewhat by comparison with the older form as regards ease of riding through a seaway. The flat under-water after body may result in a tendency to pound in a choppy

sea, while backing into a strong head sea is of course well nigh out of the question. On the other hand, the increase in average beam at the waterline, which is a pronounced feature of the flat stern, makes for stiffness and large stability for small angles of heel, though the range of stability may be no more or even less than for the older form.

So far as air resistance is concerned there is but little to choose between the two fundamental types of stern, though of all varieties in actual use the typical form with forward rake and with sharp or moderately rounded after extremity will undoubtedly show most favorably in this respect.

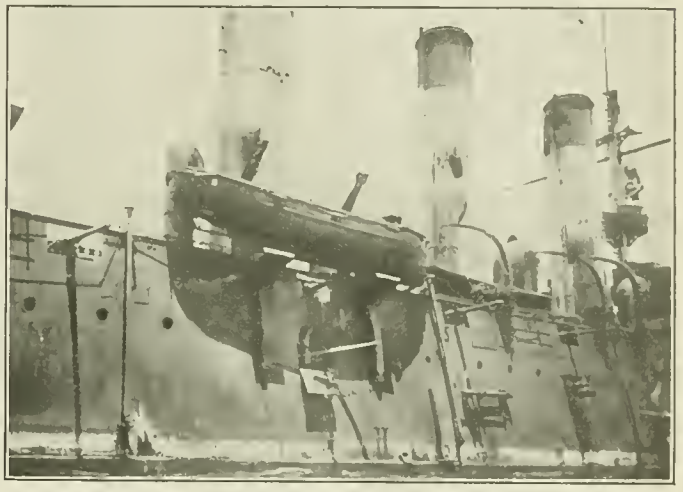
Because the flat or torpedo-boat stern has been treated thus in detail it must not be considered that it is the only form of stern used for small craft of the motor boat class. The old and conventional stern with deadwood is still met with, and in particular for boats intended for cruising purposes, and where moderately heavy weather may be expected; or, on the other hand, in boats intended for very shallow water, or when the fullest measure of protection to the propeller is desired.

Again, there are various intermediate types coming under the head of compromise sterns, and intended to retain the favorable qualities of the flat stern with respect to resistance and propulsion and at the same time to avoid some measure of the uneasiness of the full flat stern when riding in heavy weather. Such forms have usually no deadwood and show an under-water body sloping upward toward the stern, but with sections somewhat rounded or eased off at the waterline, thus avoiding the full flat characteristic of the typical torpedo-boat stern. The above-water body may be worked out in various forms according as the design leans more nearly toward the old conventional form or toward the flat torpedo-boat model. There is probably little to be gained by the use of such compromise forms beyond some slight measure of better adaptation to rough water conditions. For smooth water, or such conditions of water and weather as may be fairly considered typical for the motor boat class, the flat or full torpedo-boat stern may be accepted as generally preferable from all points of view.

Regarding the item of cockpits, trunk cabins and deck erections of all kinds, little can be said of value in a general discussion such as the present. These features pertain chiefly to utility, and their character must be determined in connection with the special needs of the case. The influence of deck erections in augmenting air resistance has been already referred to, and for high speeds so serious will this become that with small boats these features of comfort and utility must be sacrificed if the highest attainable speeds are contemplated.

The general consideration of safety has been mentioned in connection with several features of the above-water form. Some further points may be noted as follows:

It is clear that the above-water form which is ideal for smooth water conditions will be far from permissible in rough water, or even in the average weather conditions with which such boats are expected to be able to safely contend. Especially will this be true for high speed requirements, and it follows that the above-water form as related to speed in particular, and all other requirements in general, must be determined with reference to average weather conditions. In particular, will such requirement lead to modification in the ideal turtleback form of forebody. In average weather conditions a forward deck sloping down nearly to the waterline at the bow, as determined by smooth water trim, would result in the boat's running most of the time with her nose under water, and in heavy weather such a form would be quite out of the question, at least for any speed above the very slowest. While, therefore, a turtleback form is favorable to reduced air resistance, and to the rapid shedding of a wave should it break over the bow, yet its height nevertheless must be such as to lift it above the reach of the ordinary small waves, and beyond the likelihood of nosing deeply into the water under such weather conditions as are liable to be encountered. The same considerations will lead to a general increase of freeboard over that suitable for smooth water, and to other modifications of minor character intended to render the boat safe and comfortable under average weather conditions.

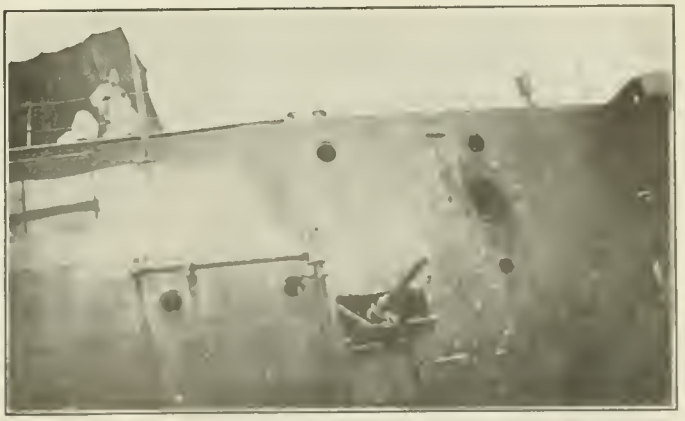


AURORA, SHOWING SHOT-HOLE OVER 3-INCH GUN.

Russian Cruisers in Manila Bay.

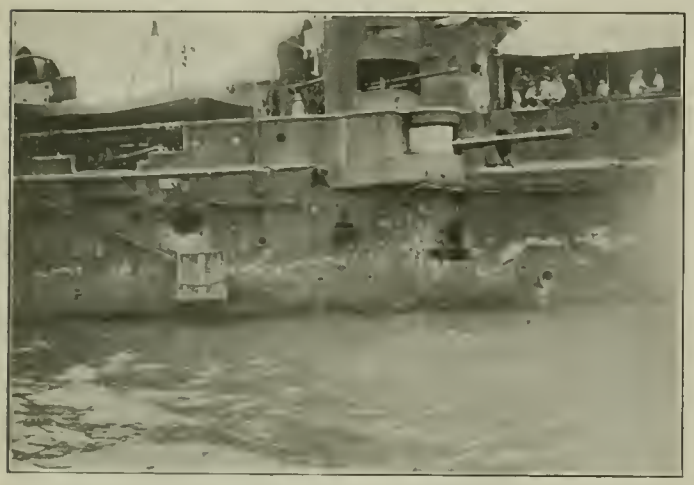
The photographs reproduced here show some results of Japanese gunnery at the battle of the Sea of Japan. The two cruisers depicted are the *Aurora* and *Oleg*. One of the shot holes shown just above a 3-inch gun opening on the *Aurora* was made by a shell which exploded on impact, put the gun out of action, and killed every man in the gun crew. Most of the other hits were not so damaging, but it will be seen that the two ships, which, with the *Jemtchug*, were the only ones to reach Manila after the

STARBOARD SIDE OF THE OLEG.



STARBOARD BOW OF THE AURORA.

battle, did so only after having been subjected to a hot fire. We are indebted for the photographs to Mr. Francis J. French, who obtained them in Manila.



THE BATTERED SIDE OF THE OLEG.

Mr. French sent us at the same time a blue print showing a target which had been fired upon by one of the 13-inch guns of the United States battleship *Wisconsin* at a range of 1,600 yards, the ship meanwhile steaming past at a speed of ten knots. This target practice, which took place February 4, 1905, resulted in the placing of twelve shots through the bullseye within a period of five minutes forty seconds, or rather more than two bullseyes per minute. When it is remembered that the 13-inch guns used at the battle of Santiago in 1898 could be fired not oftener than about once in three minutes, the above record will be seen to be a striking example of the wonderful progress made in the United States Navy in gunnery during the past seven years, while of course the absolutely clean record of bullseyes is wholly without a rival.

Calculating the Size of the Cylinders for a Multiple Expansion Engine.

BY GEORGE ELFERS.

As is well known, one of the greatest heat wastes of the steam engine is that of cylinder condensation, due to the alternate heating action of entering steam and cooling effect of expansion and condensation. This loss is reduced by steam jacketing the cylinders, superheating the steam, high compression of the exhaust steam in the clearance space and by the very common method of using two or more cylinders in series. The use of the multiple cylinder engine, in which the steam exhausted from one cylinder is used again in a succeeding one, is by far the best method of reducing the losses through cylinder condensation; and at the same time allows the use of higher ratios of expansion, resulting in an increase in the thermodynamic efficiency of the engine.

The first step in designing any engine is to determine the best ratio of expansion, for that type of engine, under the assumed conditions of operation. In one case, for instance, it might be necessary to sacrifice efficiency of the engine in order to come within the allowable limit of weight, in which case a low ratio of expansion would have to be used; then again in another case where an engine is wanted for long voyages efficiency would be paramount and a high ratio of expansion would be necessary. The total ratio of expansion varies with the steam pressure and the total number of cylinders in series. The present practice is about as follows:

Number of cylinders..	1	2	3	4
Steam pressure, in lbs..	Up to 100	90 to 150	150 to 250	200 and up
Ratio of expansion...	1.5 to 3	4 to 6	7 to 12	11 to 15

In laying out the cylinders for any multiple expansion engine it is essential that they be so proportioned as to develop about the same power in each; with this arrangement all parts of each engine undergo the same amount of wear and are under the same stress. For the purpose of illustrating the manner of solving this problem let it be assumed that we wish to calculate the diameters of the cylinders of a triple expansion engine of about 2,400 indicated horsepower; the boiler pressure being given as 200 pounds by gauge or 215 (nearly) absolute. There is always a drop in the pressure between the engine and boiler of about 10 pounds, so that the pressure of the steam at the engine, in this case, would be 205 pounds absolute.

The well known formula for horsepower is

$$I.H.P. = \frac{2 \times p_m \times L \times A \times N}{33{,}000} = \frac{p_m A\,(2LN)}{33{,}000} \quad \ldots\ldots (1)$$

in which,

$I.H.P$ = Indicated horsepower.
p_m = Mean effective pressure.
L = Length of stroke.
N = Number of revolutions per minute.
A = Area of piston in square inches.
$2LN$ = Piston speed in feet per minute.

The value of p_m, the mean effective pressure, which we may expect to get depends upon:

(1) The initial steam pressure. The higher the initial steam pressure, the higher will be the value of p_m, other things being equal.

(2) The thermodynamic efficiency designed for. The thermodynamic efficiency of any steam engine may be expressed by the equation

$$T = \frac{t_1 - t_2}{t_1 + 461},$$

where T = thermodynamic efficiency,
t_1 = the temperature of the steam at admission,
t_2 = the temperature of the steam at exhaust.

In order to lower the value of t_2 and thereby increase the efficiency, the steam must be expanded as many times as possible under the conditions of operation. The ratio of expansion can be carried too far for economy, though this is not likely to occur within the allowable limits in the diameters of low pressure cylinders and weight of engines that can be used in marine work.

(3) The weight of engine required. As the ratio of expansion increases the mean effective pressure decreases, and hence the area of the low-pressure cylinder increases, and with it the weight of engine.

For purpose of illustration, assume that a ratio of expansion of 11 has been decided upon. This is a fair value for a triple-expansion engine using steam at a pressure of about 200 pounds.

As the steam expands in the cylinder, the pressure varies inversely as the volume, and the theoretical expansion curve is a hyperbola. The mean length of the ordinates to this curve can readily be found from the equation:

$$p_m = p_1 \frac{(1 + hyp.\,log.\,r)}{r} \quad \ldots\ldots\ldots\ldots (2)$$

in which equation p_m = mean pressure,
r = ratio of expansion.
p_1 = initial pressure.
$hyp.\,log.\,r$ = hyperbolical logarithm of r.

As this equation stands it does not take into account the losses due to expansion in the receivers, wire drawing in the ports, compression, radiation, friction of the steam in passing through the ports, etc. These losses are represented by what is known as the card factor, which is equal to the ratio of the theoretical mean pressure to the actual pressure. Its value is determined from indicator cards taken from actual engines. For a triple expansion engine the card factor varies from .65 to .75, and for a quadruple from .55 to .65.

Putting the card factor equal to f, and the back pressure as p_b,

formula (2) can be rewritten

$$p_m = f\left[p_1 \frac{(1 + hyp.\ log.\ r)}{r} - p_b\right] \ldots\ldots\ldots (3)$$

Now by substituting for f, p_1 and r their values as assumed above and finding, from any handbook on engineering, the value of the hyperbolical logarithm of 11, the ratio of expansion as assumed, and allowing a back pressure p_b in the condenser of 3 pounds absolute, the value of p_m, the mean effective pressure, becomes

$$p_m = .66\left[205\frac{(1 + .2397)}{11} - 3\right] = 39.8$$

Now in formula (1) $2LN$ is the piston speed. This varies with the type of engine from about 500 feet per minute in slow-running freighters to about 1,200 in high-speed engines of the torpedo boat type. The piston speed must be assumed before the dimensions of the cylinders can be found. In this case assume a piston speed of 700 feet per minute.

In a multiple-expansion engine we may consider the steam as if expanded in a single cylinder of the same size as the low pressure. Writing formula (1) in terms of A, the area of the low pressure cylinder, we have

$$A = \frac{I.H.P. \times 33{,}000}{p_m\,(2LN)} = \frac{2{,}400 \times 33{,}000}{39.8 \times 700} = 2{,}842 \text{ square inches,}$$

equivalent diameter, 60⅛ inches.

This is the area of the low-pressure cylinder required for an engine of 2,400 indicated horsepower, running under the conditions assumed above. If the piston speed had been assumed as 750 feet per minute then the area would have come out as 2,653 square inches, or about 58¼ inches diameter.

Thus far not a word has been said about the high-pressure cylinder, to find the diameter of which it is necessary to determine the ratio of the high-pressure to that of the low-pressure. To this end it is necessary to decide upon the point of cut off in the high-pressure cylinder, and also to assume the amount of clearance this cylinder will have when actually made. In this case assume the cut off at 65 percent of the stroke, and the clearance volume as 12 percent of the cylinder volume. Then there will be $\frac{1 + .12}{.65 + .12} = 1.455$ expansions in the high-pressure cylinder. Hence, it is easily seen that the ratio of the area of the high-pressure cylinder to that of the low-pressure must be equal to the total ratio of expansion divided by the number of expansions that take place in the high-pressure cylinder, and in this case the ratios of the areas would be $11 \div 1.455 = 7.56$. The area of the low-pressure cylinder being 2,842 square inches, as found above, then the area of the high-pressure is

$$\frac{2{,}842}{7.56} = 376 \text{ square inches, or about 22 inches diameter.}$$

The area of the intermediate cylinder is made a mean proportional between the area of the high-pressure and that of the low-pressure. Hence, dividing the area of the low-pressure by the square root of the ratio of the areas of these two cylinders, in this case 7.56, the area of the intermediate-pressure cylinder is

$$\frac{2{,}842}{\sqrt{7.56}} = 1{,}033 \text{ square inches, or } 36¼ \text{ inches diameter.}$$

For different values of piston speed there will be corresponding values for the diameters of the three cylinders. Thus, any of the combinations below will give an engine of about 2,400 indicated horsepower, under the conditions of operation as assumed at the outset.

Dia. H. P.	Dia. I. P.	Dia. L. P.	Piston speed, feet per min.
22 inches	36¼ inches	60⅛ inches	700
21⅛ "	35⅛ "	58¼ "	750
20½ "	34⅛ "	56¼ "	800
19⅞ "	33 "	54⅝ "	850

The next step is to determine the stroke of the engine, which is usually about one-half of the diameter of the low-pressure cylinder, or very nearly so. Thus, in any of the above cases the stroke could be anywhere between 27 inches and 33 inches and not be out of usual proportions. As soon as the stroke has been determined, the revolutions at which the engine must run to develop the designed power can readily be found by dividing the piston speed by twice the length of stroke, in feet.

To lay out the cylinders for a quadruple expansion engine the same method of procedure is available. To illustrate, suppose that the same problem is to be solved for a quadruple engine. In this case assume a card factor of .55 and a ratio of expansion of 14. The value of p_m can then be found from the same formula as used above.

$$p_m = .55\left[205\frac{(1 + .2630)}{14} - 3\right] = 27.66 \text{ pounds.}$$

If the engine is to run at a piston speed of about 800 feet per minute, the area of the low-pressure cylinder must be equal to

$$A = \frac{33{,}000\ I.H.P.}{(2 \times L \times N)\ p_m} = \frac{33{,}000 \times 2{,}400}{800 \times 27.66} = 3{,}580.$$

If we consider the point of cut off and the clearance of the high-pressure cylinder to be the same as in the above case, then the number of expansions of steam in the high-pressure will be the same, 1.455, and since there are to be 14 expansions in all, the ratio of the area of the low-pressure to that of the high-pressure will be $\frac{14}{1.455} = 9.62$

Now let A_1 A_2 A_3 be equal to the areas of the high-pressure, first intermediate-pressure and second intermediate-pressure, respectively. Then from above

$$A_1 = \frac{3{,}580}{9.62} = 372 \text{ square inches.}$$

Now $A_1 : A_2 = A_3 :$ Area of low-pressure or $A_1 : A_2 = 1 : \sqrt[3]{9.62}$

Hence $A_2 = \sqrt[3]{9.62} \times A_1 = 2.13 \times 372 = 792$ square inches.

Also $A_2 : A_3 = 1 : \sqrt[3]{9.62}$

$A_3 = \sqrt[3]{9.62} \times A_2 = 2.13 \times 792 = 1{,}686$ square inches.

which is equal to the area of the second intermediate-pressure cylinder.

Thus, we have the areas of the four cylinders when the piston speed is assumed to be 800 feet per minute. For any other piston speed an entirely new set of values for the areas of the cylinders will be found when solved as above. Having found the required areas of the several cylinders it is an easy matter to solve for the diameter. The quadruple expansion engine will be heavier than the triple, but the coal consumption of the latter will be somewhat the greater.

Oil Fuel for War Ships.—A British Admiralty committee has evolved a burner for oil fuel on board ship, and practically all the British warships now building will be so fitted that oil may be used as an alternative to coal. The various contractors are pledged not to divulge the details of the burner, upon which depends the economy of the system. Oil fuel will not be continuously used in the British naval service, but ships in commission will use it often enough to insure that the system is kept in satisfactory condition, and the staff experienced in its application. The chief advantage claimed for oil fuel is its high evaporative power. Under the best theoretical conditions each pound of oil should generate 20 pounds of steam, from and at 212 degrees Fahrenheit, but this is never realized in practice. The elaborate tests conducted by the United States Navy Department indicated that in ordinary service each pound of oil would generate from 12 to 13 pounds of steam, from and at 212 degrees Fahrenheit. This is about 40 percent more than can be got from the best Welsh coal, but in the British service better efficiency is obtained with the new burners. One of the best results was

achieved in some tests made by Professor Watkinson, of Glasgow, with a system worked out in Glasgow by the Local Light and Heating Company. Under normal conditions, 16 pounds of steam were generated per pound of oil and the amount of steam used for the atomizing and vaporizing of the oil was only 1½ percent of that generated, as compared with 4½ percent in the United States navy tests. Oil fuel need not affect the boilers if the necessary safeguards are taken. In many merchant ships using the system the back and sides of the combustion chamber are protected with brick work carried up above the level of the crown of the furnace, while the furnace also is bricked, and brick baffles are fitted to break up the torch-shaped flame within the furnace itself. The oil in warships will be carried in the double bottom, the usual coal bunkers being retained alongside the machinery and boiler spaces.

SHIPBUILDING IN THE UNITED STATES IN 1905.

Through the courtesy of the Bureau of Navigation, we are enabled to present figures covering the shipbuilding operations in this country during the past year. These figures are exact up to the end of November, while the computation is carried on to December 31, by means of an estimate based on the December tonnage of previous years as compared with the eleven months of the year prior to December. This information is given in four tables, the first of which shows the total of all mercantile vessels built in the United States (aside from unrigged barges) for the calendar years 1900 to 1905 inclusive, and shows that the high-water mark was reached in 1902, with 434,000 tons of shipping. It will be noticed from this table that the average size of ships included is very small, in no case exceeding for any year 350 tons. This is due to the fact, of course, that there

VESSELS BUILT IN THE UNITED STATES.

Year.	Ships.	Gross Tons.	Average Tons.	Great Lakes Ships.	
				Gross Tons.	Percent.
1900	1,102	365,791	332	129,973	35.6
1901	1,322	376,129	284	156,157	41.5
1902	1,270	434,005	342	158 230	36.5
1903	1,159	381,970	330	182,593	47.8
1904	1,063	265,104	249	54,042	20.4
1905	1,036	311,611	300	189,981	61

are included in the figures vessels of all sizes down to the smallest, many of which are of very small value so far as shipping as a whole is concerned. Another column of this table shows the tonnage constructed on the Great Lakes in these several years, and the percentage of this tonnage to the total is also given. It will be seen that this percentage, which averaged about forty during the first four years of the period, exceeded sixty in 1905.

Taking the most important class of ships constructed, namely, steel vessels propelled by steam, we show in another table figures for each six months for the same period of six years, the figures

STEAM STEEL VESSELS BUILT IN THE UNITED STATES.

Six Months, Ending	Totals.		Atlantic and Gulf.		Great Lakes.	
	Ships.	Gross Tons.	Ships.	Gross Tons.	Ships.	Gross Tons.
June 30, 1900	52	105 713	31	34,803	17	63,885
Dec. 31, 1900	40	91,244	20	44.179	16	44.626
June 30, 1901	64	144 021	31	46,297	30	91,934
Dec. 31, 1901	40	74 604	21	25,541	17	49,020
June 30, 1902	74	196,197	34	76,186	32	109,019
Dec. 31, 1902	42	98.516	26	52,385	12	43,248
June 30, 1903	69	153,389	33	54.411	29	88,412
Dec. 31, 1903	50	126,392	20	36,077	28	89,562
June 30, 1904	43	113,261	27	61.904	13	50,336
Dec. 31, 1904	31	19.472	25	16,055	8	2 498
June 30, 1905	42	139,883	17	39,822	24	99,999
Dec. 31, 1905	47	104 925	22	18,309	23	86 302

for December being estimated as before. These figures show the continuous reduction in tonnage on the Atlantic and Gulf during the past two or three years, while it is further shown that the tonnage on the Great Lakes in 1905 was greater than in any previous year. These tonnages by years are further shown graphically in the chart presented herewith, which gives an idea as to the gradual decadence on the Atlantic coast and the general increase with the exception of one year on the Great Lakes.

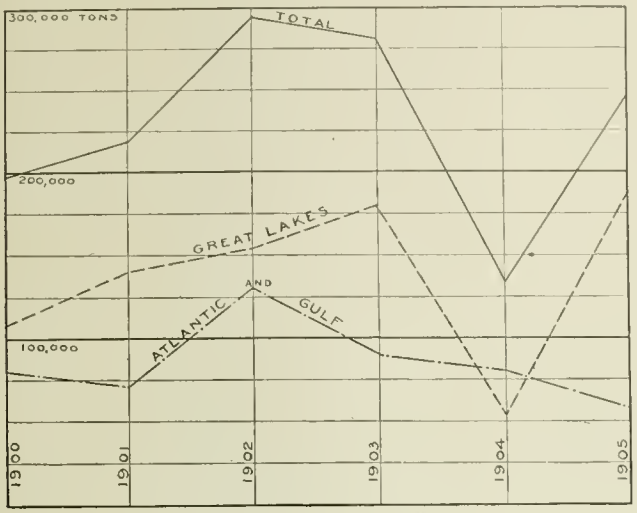
SEABOARD. Steel Steamers.	Tons	Built.	Owner or Builder.
Dakota	20,714	New London, Conn.	Great Northern S.S. Co.
Providence	4,365	Quincy, Mass.	Old Colony Steamboat Co.
Chippewa	2,696	Philadelphia, Pa.	Clyde S. S. Co.
Onondaga	2,696	Philadelphia, Pa.	Clyde S. S. Co.
Manhattan	2,006	Sparrows Point, Md.	New York City.
Brooklyn	2,006	Sparrows Point, Md.	New York City.
Bronx	2 006	Sparrows Point, Md.	New York City.
Queens	2,006	Sparrows Point, Md.	New York City.
Richmond	2,006	Port Richmond, N. Y.	New York City.
Elmira	1,460	Newport News, Va.	D. L. & W. R. R. Co.
Goshen	1,459	Wilmington, Del.	Erie Land & Improvem't Co.
Car Float No. 2	1,374	San Francisco, Cal.	So. Pac. R. R. Co.
San Francisco (wood).	1,070	Alameda, Cal.	S. F., O. & S. J. R. R. Co.
(Thirteen)	45,864	Average, 3,528 tons.	
GREAT LAKES. Steel Steamers.			
William C. Mather	6,838	Ecorse, Mich.	Cleveland Cliffs Iron Co.
James C. Wallace	6,684	Lorain, O.	American Shipbuilding Co.
Joseph G. Butler, Jr.	6,588	Lorain, O.	American Shipbuilding Co.
William A. Rogers	6,524	Lorain, O.	American Shipbuilding Co.
Henry C. Frick	6,490	West Bay City, Mich.	Pittsburg S. S. Co.
George W. Perkins	6,466	Superior, Wis.	Superior Shipbuilding Co.
William E. Corey	6,363	Chicago, Ill.	Pittsburg S. S. Co.
Leonard C. Hanna	6,356	Cleveland, O.	American Shipbuilding Co.
Elbert H. Gary	6,331	Chicago, Ill.	American Shipbuilding Co.
Amasa Stone	6,282	Wyandotte, Mich.	Mesaba S. S. Co.
Socapa	6,272	West Bay City, Mich.	Superior S. S. Co.
Sylvania	6,272	West Bay City, Mich.	W. Bay City Shipbuilding Co.
James E. Davidson	6,206	Ecorse, Mich.	Great Lakes Engin'g Works.
Lyman C. Smith	6,200	Wyandotte, Mich.	Lyman C. Smith Transit Co.
Peter White	6,184	Ecorse, Mich.	Presque Isle Transport'n Co.
Powell Stackhouse	6,171	Wyandotte, Mich.	Mahoning S. S. Co.
John Stanton	6 129	Lorain, O.	American Shipbuilding Co.
Philip Minch	5 865	Lorain, O.	American Shipbuilding Co.
Hoover & Mason	5,841	Ecorse, Mich.	Great Lakes Engin'g Works.
Stephen M. Clement	5,821	Lorain, O.	Buf. & Susquehanna S. S. Co.
William A. Paine	5,798	Cleveland, O.	Pioneer S. S. Co.
Ball Brothers	5,733	Lorain, O.	American Shipbuilding Co.
James P. Walsh	5,630	Toledo, O.	Craig Shipbuilding Co.
George H. Russell	4 978	St. Clair, Mich.	St. Clair Engineering Works.
Frank J. Hecker	4,978	St. Clair, Mich.	St. Clair Engineering Works.
Superior	4 544	Ecorse, Mich.	Western Transit Co.
Juniata	4.333	Cleveland, O.	American Shipbuilding Co.
Francis L. Robbins	4.222	Cleveland, O.	American Shipbuilding Co.
Delaware	3,901	Ecorse, Mich.	Erie & West. Transp'n Co.
Marquette & Bessemer No. 2	2,514	Cleveland, O.	American Shipbuilding Co.
(Thirty)	171,018	Average, 5,701 tons.	

The third table covers the construction of steel steamers of over 1,000 tons each during the year. It will be noted that thirteen of these steamers only are seaboard, eleven having been constructed on the Atlantic and two on the Pacific.

These thirteen have an aggregate of 45,864 gross tons, or an average of 3,528. If we omit the gigantic *Dakota*, the construction of which having extended over several years belongs properly to a previous period, we have twelve ships of an aggregate of 25,150 tons or an average of 2,096. Compared with this, we have on the Great Lakes a splendid array of thirty ships, aggregating 171,018 tons, or an average of 5,701. This average is greater than the tonnage of the largest ship built on the seacoast, with the sole exception of the *Dakota*, while the smallest of these thirty lake ships has a greater tonnage than the average on the seaboard, if we omit the *Dakota*. The next smallest on the lakes has a greater tonnage than the average on the seaboard, even including the *Dakota*. It will further be noted that with the sole exception of the *Dakota* every one of the ships built on the seaboard is designed for either coastwise traffic or ferryboat or similar service.

We have received from a number of the important seacoast shipyards of the United States information regarding the shipping in hand at the close of the year, and we present this in a fourth table which explains itself. It will be noted that the table represents 27 ships of a gross tonnage amounting to 98,215, or an

average of 3,638 tons, besides 17 ships, mostly small, of which the tonnage is not given. This is in addition to warships aggregating 28 in number, with a total displacement of 313,350 tons.



THE TREND OF MERCHANT SHIPBUILDING.

On the lakes orders are in hand for thirty-one large steel ships under contract to come out in the spring and early summer of 1906. Twenty-six of these ships have been ordered from the American Shipbuilding Company, four from the Great Lakes Engineering Works, and one from the Craig Shipbuilding Company, Toledo. It is estimated that these thirty-one vessels will be able to carry about 270,000 gross tons per trip, or a total of 5,400,000 tons during the season. The total cost is placed at $10,500,000. With the exception of one of these ships, which is a package freighter, all are designed for bulk cargo in the shape of ore and grain.

FORE RIVER SHIPBUILDING CO., QUINCY, MASS.

Ship.	Tons Gross.	Length.	Knots.	Owner.
Creole (*a*).....	6,000	440	16	Southern Pacific Co.
South Shore (*b*)....	750	208	15	Nantasket Beach Co.

MARVEL SHIPBUILDING CO., NEWBURG, N. Y.

Hudson River Day Line steamer (hull only).

ROACH SHIPYARD, CHESTER, PA.

	Tons Gross.	Length.	Knots.	Owner.
Steamer	3,000	285	14	New England Nav. Co.
Steamer (*a*).....	3,650	305	17.5	Eastern S. S. Co.
Steamer (*a*).....	4,800	405	20	Metropolitan S. S. Co.
Steamer (*a*).....	4,800	405	20	Metropolitan S. S. Co.

WILLIAM CRAMP & SONS, PHILADELPHIA.

	Tons Gross.	Length.	H.P.	Owner.
Transfer tug.....	276	112	1,000	N. Y., N. H. & H. R. R.
John Weaver.....	1,700	200	3,800	City of Philadelphia.
Two steamers.....	7,000	400	6,000	N. Y. & Cuba Mail.
Two steamers.....	7,200	413	8,500	N. Y. & Cuba Mail.
Two steamers.....	7,500	421	7,000	Southern Pacific Co.
Three steamers.....	3,500	375	7,600	Quintard Iron Works.

NEW YORK SHIPBUILDING CO., CAMDEN, N. J.

One suction dredge for Atlantic, Gulf & Pacific Co.
Two suction dredges for Empire Engineering Co., New York.

MARYLAND STEEL CO., SPARROWS POINT, MD.

	Tons Gross.	Length.	H.P.	Owner.
Delaware (dredge)..	2,700	300	.....	United States.
Three tugs.....	.....	91	.....	Pennsylvania R. R. Co.
One tug.....	.....	106	.....	Pennsylvania R. R. Co.
One float.....	.....	340	.....	Pennsylvania R. R. Co.
Two floats.....	.....	185	.....	Standard Oil Co.
Six floats.....	.....	111	.....	Panama R. R. Co.

NEWPORT NEWS (VA.) SHIPBUILDING AND DRYDOCK CO.

	Tons Gross.	Length.	Knots.	
Syracuse.....	450	101	9(*c*)	(freight lighter)
W. S. Porter.....	4,527	385	11	(freighter)
Jamestown.....	1,400	250	18(*c*)	(passenger steamer)
Ferryboat.....	1,462	231	15(*c*)	

UNION IRON WORKS, SAN FRANCISCO, CAL.

	Tons Gross.	Length.	Owner.
Mexican.....	4,400	360	American-Hawaiian S. S. Co.
Columbian.....	4,400	360	American-Hawaiian S. S. Co.

(*a*) Propelled by Curtis steam turbines. (*b*) Propelled by paddle-wheels. (*c*) Miles per hour.

Marine Thrust Bearings.*

G. W. DICKIE: Judging from the rapid introduction of the steam turbine for ship propulsion, the thrust bearing, which has played so important a part in marine steam engineering, is in danger of losing its importance in marine engine design, the thrust of the propeller on the one end of the shaft being balanced by the thrust of the turbine on the other end. This "defect" in the Parsons turbine, the end thrust, is a great advantage when applied to screw propelled ships, for it balances the thrust of the screw, thus saving the very material loss by friction of the thrust bearing, and renders the Parsons turbine an ideal form of motor for ships. Still for some time to come we will require thrust bearings for marine engines, and an inquiry as to what the main features in a well-designed bearing of this character should be will be time well spent.

The marine thrust bearing has not changed in type since the introduction of screw propulsion, although many attempts have been made to introduce some kind of ball or roller bearing with the object of reducing the friction of the extended rubbing surface of the bearing, but no one of such devices has succeeded in permanently taking the place of the collar and ring thrust. The adoption of the horseshoe ring, better workmanship, and improved methods of lubrication, together with water-cooling devices, have brought the marine thrust bearing to its present efficiency.

The function of the thrust bearing renders it difficult to experiment with for data; it has, therefore, developed along the line of meeting pressure with surface, making provision so that all the surface involved will take load, lubricating and watching the result. In computing the pressure on a thrust bearing the usual practice is to find the indicated thrust, assuming two-thirds of the indicated horsepower to be effective; the result will be somewhat in excess of the actual thrust even in the best of cases, the pressure on thrust bearings being,

$$P = I.H.P. \times \frac{2 \times 60 \times 33{,}000}{S \times 3 \times 6{,}080} = 217 \frac{I.H.P.}{S}$$

where P = pressure on thrust bearing, S = speed of ship in knots. Applying this to several types which cover general practice, and which I have taken from my own work which proved to be satisfactory:

I. Armored cruiser, speed.....	22 knots
Thrust ring surface, horseshoe type.....	1,188 square inches
Horsepower, one engine.....	11,500
Indicated pressure or thrust on bearing..	112,700 pounds
Pressure per square inch of surface.....	95 pounds
Mean speed of bearing surfaces.....	642 feet per minute

This would represent fairly naval marine engine practice, and, under the full power conditions as given above, the thrust bearing needs careful watching. The length of the bearing proper, from the after face of the after horseshoe to the after face of the forward horseshoe, being 72 inches, the danger is that any part of the bearing getting hot may so change the relative distance between the shaft collars and the thrust rings as to disturb the distribution of load and leave part of the bearing out of service. I think that I was the first to make the horseshoe rings with an independent circulation of cooling water through each ring. This enables the attendant to control the heat of each ring independently, and thus maintain an even temperature throughout the whole bearing. The base of the bearing forms an oil reservoir, the bearing at each end having a stuffing box so that the oil can be carried above the lower line of the shaft; a cold water coil is fitted in the oil chamber to keep down the temperature. I find that a small surface is sufficient for this purpose where the horseshoe rings are fitted with water circulation. The bearing noted above has 15 feet of cooling surface for the lubricating oil.

*Discussions before American Society of Mechanical Engineers, December 7, 1905.

II. Protected cruiser, speed	22½	knots
Thrust ring surface, horseshoe type	891	square inches
Horsepower of one engine	8,600	
Indicated pressure or thrust on bearing	89,000	pounds
Pressure per square inch of surface	100	pounds
Mean speed of bearing surfaces	610	feet per minute

This bearing was fitted with independent water circulation through each horseshoe ring like the first case, and with 10 feet of cooling surface for the lubricating oil the working proved very satisfactory, the thrust bearing requiring no more care than the other bearings of the engine.

III. Torpedo boat destroyer, speed	28	knots
Thrust ring surface, complete rings	581	square inches
Horsepower of one engine	4,200	
Indicated pressure or thrust on bearing	33,600	pounds
Pressure per square inch of surface	58	pounds
Mean speed of bearing surfaces	827	feet per minute

This bearing was fitted with a complete water jacket and required a large stream of water to control the temperature at full power, and constant care was necessary during the two hours' full-power run. It will be noted that the pressure per square inch of surface was much less than that of the other cases, but the surface velocity was much higher.

IV. First-class modern passenger ship, speed	21	knots
Thrust ring surface, horseshoe rings	2,268	square inches
Horsepower of one engine	15,000	
Indicated pressure or thrust on bearing	154,500	pounds
Pressure per square inch of surface	68.1	pounds
Mean speed of bearing surfaces	504	feet per minute

In this case there is no independent water circulation through the horseshoe, and the bearing gives no unusual trouble. It will be noted that in this case the bearing surface speed is less than in the others, and consequently lubrication is more certain.

There is considerable difference in the practice of prominent marine engine builders in regard to thrust bearings, but generally it will be found that for steady work the pressure per square inch of surface should not exceed 75 pounds with a speed of 500 feet per minute.

A. M. Mattice: The central gravity system of lubrication which has come into extensive use in engine installations within the past few years has resulted in a marked saving in cost of lubrication and the elimination of bearing troubles, and the details of such systems are well worth the serious attention of engineers. I refer to the systems which, while varying in details, comprise essentially an overhead supply tank, pipes leading to all bearings with valves for regulating the supply, arrangements for catching the overflow oil, settling tanks, filters, and pumps for returning the oil to the supply tank; the whole system being automatic, and resulting in a continuous circulation of oil. Although this system is at present used principally in large installations, it has been used with success in smaller plants, and I believe that engineers would be fully justified in using it in installations of single engines of large or even moderate size. Its success is due not only to the saving of labor, as in large installations, but by supplying an excess of oil to the bearings the oil does not become "worn out," as in the drop-by-drop system, resulting in a reduction of oil bills.

A further extension of the principle of continuous circulation of oil obtains in the flooded system of lubrication which has come into use in connection with steam turbines. In fact, this system was introduced by Parsons before the central gravity system for reciprocating engines came into vogue. This system consists in supplying to the bearings as much oil as will flow through them; the oil carrying away the heat of the bearings and being cooled in a tubular cooler before going back to the bearings again. The oil is not forced into the bearings under pressure, but simply supplied at a head of from a few inches to several feet—just enough to allow it to flow freely to the bearings. As the oil is nowhere exposed to the outside air, circulating only in a closed system, it collects no dirt and does not need to be filtered, but is used over and over again continuously, the entire oil supply circulating through the bearings every few minutes.

By means of the system, speeds and pressures are used which would otherwise be impossible, and, what is of still greater interest to the owner, the oil consumption is reduced to a minimum. As instances of this I would cite the cases of two installations of 400-kilowatt steam turbines of the Parsons type, running at 3,600 revolutions per minute; one used only 50 gallons of oil in six months, and the other one 55 gallons. At another plant one turbine of 40 kilowatts and another of 750 kilowatts used only three barrels of oil in sixteen months. In another case two 1,000-kilowatt turbines used one-half gallon of oil per turbine-week.

I crossed the Atlantic last summer in the turbine steamer *Virginian,* and upon investigating I found that no oil had been added to the tanks for four successive round trips between Liverpool and Montreal, and the supply had not appreciably diminished. The service tank has a total capacity of 293 United States gallons, but only 144 gallons of oil had been put in, and this was being circulated through the bearings at the rate of from 40 to 50 gallons per minute, the whole supply being circulated in less than every four minutes.

The turbine steamer *Queen Alexandra,* which in the summer season makes daily trips on the Clyde, used less than one barrel of oil during a season of between four and five months.

The oil consumptions of turbine steamers above quoted are for the bearings of the turbines proper, each steamer having three turbines. The line shaft bearings have ordinary lubrication, but I have no doubt that before long it will become the practice to use on such bearings the same system of flooded lubrication as on the bearings of the turbines themselves.

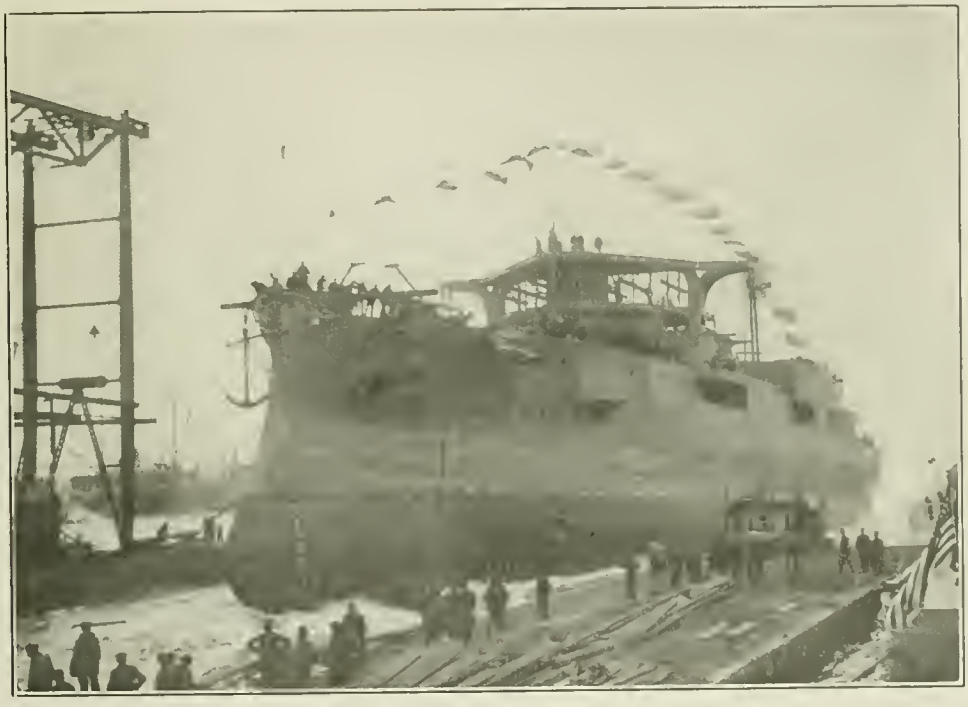
The Battleship Agamemnon and Beardmore's New Shipyard.

The construction of the new battleship *Agamemnon* inaugurates the new naval construction works of Messrs. William Beardmore & Company, Limited, at Dalmuir, near Glasgow. The event is of some historical interest. This ship is the first battleship designed by Mr. Philip Watts, as Director of Naval Construction. She will be the most powerful ship of the line in existence, and she is the first warship to be commenced at the new works of the Beardmore company. The *Agamemnon* is to be 410 feet long between perpendiculars, and her displacement at 27 feet draft will be 16,500 tons. She will have the greater part of her length broadside armored with hardened plates varying from 9 inches to 7 inches in thickness from over 5 feet below the waterline to the upper deck. Her extremities will be protected by armor varying in thickness down to 4 inches. Her armament of four 12-inch guns is to be in pairs in centrally located barbettes forward and aft, while on each broadside there will be five 9.2-inch guns. For bow or stern firing there will be two 12-inch and four 9.2-inch weapons, and for broadside attack four 12-inch and five 9.2-inch pieces will be available. The guns will be of longer caliber than in any recent ships, and will develop a greater energy. The propelling machinery is to be of 16,750 indicated horsepower, to give a speed of 18 knots.

The new works at which the building of this ship has been commenced are of the most up-to-date character. Steam is dispensed with and power is generated in immense gas engines worked with producer gas. The producers also supply the gas for the furnaces, where plates, angles, etc., are worked to form. The engines drive Vickers electric generators, which provide the power for the motors at the machine tools, cranes, etc. The smith and forging hammers are operated by air, and the compressors are actuated also by gas engines. In the arrangement and equipment of the works the most approved practice has been adopted.

Naval construction at their works follows the conclusion of the

long career of Napier's yard and the Lancefield Forge and Engine Works recently acquired by the Beardmore company and now dispensed with in favor of the new establishment. The oldest foreman in the old Lancefield works was employed to cut off steam from the engine with the ceasing of active life in one of the oldest engine works in the country. The famous Robert Napier leased Lancefield from his cousin David in 1835 for £500 a year, with the option of a sale for £20,000. From the old works there have been sent forth many historical engines, including those for all the Cunard liners up to the last of the paddle engines, and the first of triple-expansion engines for liners and warships. The Govan yard was opened in 1842, the first ship being the *Vanguard*, of 700 tons, for the Glasgow and Dublin trade, followed by a long series of successes in merchant and naval ships. Under the Beardmore company these establishments are now associated with the Beardmore armor plate and forging businesses.



THE IDAHO LEAVING THE WAYS.
(Photo. W. H. Rau.)

The Launching of the Idaho.

On Saturday, December 9, 1905, the New United States battleship *Idaho* was launched from the ways of the Wm. Cramp & Sons' Ship & Engine Building Company, of Philadelphia.

The *Idaho* is a first-class battleship, having a length of 375 feet, a beam of 77 feet, and a mean draft of 24 feet 8 inches, corresponding with a displacement under normal conditions of 13,000 tons. She is to be propelled by twin-screw, triple-expansion engines, giving an indicated horsepower of 10,000 and providing the ship with a speed of 17 knots. The normal coal supply amounts to 600 tons, while the total bunker capacity is estimated at 1,750 tons.

The ship has a battery consisting of four 12-inch, eight 8-inch and eight 7-inch breech-loading rifles; with a secondary battery containing twelve 3-inch, six 3-pounder, four 1-pounder, eight machine and two field guns, with two 18-inch submerged torpedo tubes.

The armor consists of a waterline belt having a thickness amidships of 9 inches, with thinner armor above the belt, forming a casemate. The barbettes for the 12-inch guns have a thickness of 10 inches on the face and 7½ inches in the rear, with corresponding turrets 12 inches and 8 inches in thickness. For the 8-inch guns the barbettes have a thickness of 6 and 4 inches respectively, and turrets 6½ and 6 inches. The protective deck has a thickness of 3 inches on the slopes and 1½ inches on the flat. The complement consists of thirty-four officers and six hundred and ninety-one men.

The *Idaho* is in all respects similar to the *Mississippi*, description of which was published at page 467 in our November number.

A Boiler Tube Question.—The relative merits of vertical and horizontal boiler tubes have been before the North of England Institution of Shipbuilders and Engineers. In a comparison of vertical and horizontal tubes, in water-tube boilers, many controversial points were raised, and in respect to fuel economy it was contended that vertical tubes, small in diameter, are preferable to horizontal ones. But it was admitted that it is equally important that the gases, on leaving the combustion chamber to enter among the tubes, should not rush through to the funnel too quickly, but that enough time should be allowed them to give up their heat. This is characterized as the crux of the efficiency question in all vertical tube boilers, and is the reason why the horizontal tube boiler with baffles has been preferred for practically all but light craft, where the minimizing of weight is a dominant consideration. The gases should be split up into as many narrow streams as possible. A reduction in scantlings involves sacrifices of durability and of safety; less water space is against accessibility, and a smaller steam drum tends to wet steam; indeed, it is said that the small steam space in boilers has given the whole class of steam generators a bad name. Flat-stayed surfaces are probably the most expensive item in boiler work; but there are only two or three boilers of less known types with these. The securing of tubes by expansion rather than by screwing them into the tube plate or header is cheaper. Casings when brick lined are costly, and bricks are not always suitable on board ship. Straight tubes are preferable for cleaning internally, and vertical tubes have an advantage, as they have the minimum amount of external deposit. The horizontal tube generally lends itself well to renewal, as with vertical tubes it frequently happens that good tubes have to be cut away to get at a defective one. But each type must be considered on its individual merits, and upon the predominant qualities of each particular case. A boiler suited to a destroyer would not do for a tramp steamer.

Marine Engineering

Published Monthly by

MARINE ENGINEERING

INCORPORATED.

17 Battery Place, - - - NEW YORK

12 St. Benet Place, Gracechurch St., LONDON, E. C.

H. L. ALDRICH, President and Treasurer

PROF. W. F. DURAND, Advisory Editor

SIDNEY GRAVES KOON, Editor

GEORGE SLATE,
Vice-President and Advertising Representative

Branch Offices. Philadelphia, Pa., Machinery Dept., The Bourse, S. W. Anness.
Boston, Mass., 170 Summer St., S. I. Carpenter.
Chicago, 34 Clark Street, Howard S. Moss.

TERMS OF SUBSCRIPTION.

	Per Year.	Per Copy.
United States, Canada and Mexico	$2.00	20 cents
Other countries in Postal Union	10/6	1/-

Entered at New York Post Office as second-class matter.

Copyright, 1905, by Marine Engineering, Inc., New York.
Marine Engineering is registered in the United States Patent Office.

Notice to Advertisers.

Changes to be made in copy, or in orders for advertisements, must be in our hands, in New York, not later than the 10th of the month, and in London, for the English edition, not later than the 20th, to insure the carrying out of such instructions in the issue of the month following.

The edition of the January issue of Marine Engineering *comprises 5,500 copies. We have no free list, accept no return copies and issue only enough to supply the regular demand, so that the 5,500 copies represent legitimate circulation.*

Shipbuilding in the United States.

In another column we have given a résumé of the shipbuilding situation in the United States, both as regards ships constructed during the year 1905, and those in hand at the present time. The situation on the seacoast is very far from encouraging. It will be seen by reference to the tables and the diagram presented that the tonnage constructed for sea-going traffic has undergone a continuous decrease during the past three or four years, and has reached a point where a much further decrease would result in its total disappearance. We do not anticipate any such result as this, however, because there will always be a certain amount of work in connection with providing ships for coastwise traffic; but so far as over-sea trade is concerned, the amount of shipbuilding seems likely to diminish to zero unless something is done to relieve the situation. Fortunately, it begins to appear likely that Congress will at the present session take up seriously the shipping question, and it is believed in quarters usually well informed on such subjects that some sort of relief will be afforded by means of a bill passed. Unless something of this sort comes to a head, we may certainly look for an absolute cessation in American shipyards of all work covering transoceanic traffic. Conditions have reached almost the lowest possible ebb, so that they cannot be very much worse than they are at present, and any change which may be made must be for the better. We are exceedingly hopeful of some assistance from Congress through the medium of the merchant marine bill, and sincerely trust that nothing may intervene to prevent its speedy passage.

On the lakes no such condition exists. The yards are very busy, having in many cases all the work they can handle for the next year, and, with the immense expansion of the iron and steel business which has been taking place during the present year, and which furnishes a very large proportion of the freight carried by these steamers, there is not in sight any cause which might lead us to expect a retardation of this business. Such action as Congress may take in the matter will not affect lake shipping in the least, nor is there any reason why it should be expected to do so; but this particular phase of the shipping industry, giving us as it does a splendid indication of what that industry can be made under proper conditions, ought to give us great encouragement with regard to what the situation on the seacoast will be when the merchant marine bill finally becomes a law.

Naval Engineers.

In his report, the Chief of the Bureau of Steam Engineering in the Navy Department takes up the question of naval engineers, which he admits to be in a critical condition. Recognizing the fact that at the time of the enactment of the personnel bill a whole corps of specialists was virtually abolished, and the duties previously performed by these specialists transferred to the line, the intent of that bill is stated to have had in view the perfecting of all the younger officers of the engineering corps in seamanship, gunnery and navigation; and at the same time the younger officers of the line were to perfect themselves in engineering duties, and thereafter all of these officers of both divisions were to perform indiscriminately the joint duties. It was expected that this would result eventually in providing a line composed wholly of officers fitted to perform all duties connected with the movement of ships.

The younger officers of the engineer corps, in the two years in which they were given to qualify for their new duties, attained an eminent fitness for them, and it may be said that all officers now in the navy are properly qualified to perform the duties usually devolving upon the line officer.

On the other hand, as all midshipmen at the academy had been given during their course excellent practical instruction in engineering, no additional examination was demanded of them, except that required for promotion, in order to prove their qualifications for the performance of the new duties thrust upon them. The

intent was, however, that they should be ordered at once to the performance of this duty in subordinate capacities as assistants to the older engineer officers. Owing to the absence of specific instructions to that effect in the personnel bill, combined with powerful adverse influences within the department itself, it resulted that for three years absolutely nothing was done by the younger line officers, in the direction of acquiring engineering experience; and later, owing to the large number of ships kept in commission, and the relative scarcity of officers for all duties, little in that direction has been accomplished.

In the meanwhile the older officers of the engineer corps, partly by retirement and partly by promotion to a rank at and beyond which they could not legally be called upon for sea duty, have dwindled to a mere handful; so long as they remained available for service at sea, and were supplemented by the new body of warrant machinists, the engineering duty of the fleet was properly performed. At the present time, however, there are so few of the old officers available for service, and so few of the younger line officers have attained any considerable degree of perfection in engineering experience, that the conduct of the machinery of our ships is entrusted for the most part to warrant machinists, supervised in the larger class of vessels by in many cases a single officer of responsibility, and the number of such officers is rapidly diminishing, having been sixty-six a year ago and only forty-three at the present time. So few officers of the line are taking up engineering seriously that the situation is becoming positively alarming.

The Bureau recommends that there be no formation of a separate corps of engineers; and that there be a large increase in the number of warrant machinists. We are fully in accord with the latter recommendation, for the reason that the only method apparent for providing the immediate increase in the engineering staff which the conditions of the service render absolutely necessary seems to be an increase in this branch. As to the formation of a second corps of engineers, that subject is decidedly open to argument. As we have pointed out time and again, the position is one calling for a very highly trained class of specialists. It has been suggested that all officers of the navy be made engineers first, and line officers afterward. This would provide for the specialists required, and would be eminently logical; for the subjects not covered by regular duties of engineer officers are such that men of the caliber of those graduated from Annapolis can quickly acquire proficiency in them. It would thus seem advisable to follow out the Bureau's suggestion of not forming a separate corps of engineers but of making all officers engineers. This would provide our ships with commanders and other officers who would be thoroughly conversant with the demands of the engineering service, and would further result in entirely eliminating a great deal of the friction and misunderstanding unavoidably connected with the present method of handling the ships. It would, furthermore, result in placing the engineering force as such under the command of officers responsible for the ship as a whole, instead of placing them under the dual command of engineering officers without authority beyond their own departments, and line officers claiming authority in every department, and, in many cases, thoughtlessly issuing orders decidedly prejudicial to the proper conduct of the engineering department.

The Bureau recommends that there be no introduction of outsiders into the engineering personnel, believing that graduates of the Naval Academy can fulfil all duties required. This recommendation is not supported by the Secretary of the Navy in his annual report. He recommends that for engineering duty on shore, such as the designing of marine engines and boilers and the inspection of constructions and material, there be organized a corps of men from civil life, graduates of our great technical schools, who shall be given this duty in order to release from it for sea duty engineering graduates of Annapolis. This recommendation of the Secretary seems to us a very good one, and we hope it will prove but an entering wedge providing for a much larger use in the navy of our technical graduates, under conditions such that they can reasonably be expected to take up this work with the intention of making it a life work. This wish is actuated by our thorough belief that the resources of the Naval Academy for providing a sufficient number of engineer officers well trained for the duties required of them are totally inadequate to the needs of the situation; besides which the experience necessary for placing these officers in positions of responsibility cannot be obtained without the expenditure of a considerable amount of time; and we believe that this time is not available: the situation demands immediate relief.

In conversation some days ago with one of the old engineer officers of the navy, now retired, the Editor was informed by this officer that the first ship of which he had the honor to be chief engineer had machinery of 800 horsepower. He had as assistants four graduates of Annapolis, who were serving in subordinate capacities under him and acquiring the necessary engineering experience to fit them for the duties which ultimately fell to their lot. The last engineering assignment of this officer before his retirement saw him as chief engineer of one of our latest battleships, whose engines indicated on trial about 12,000 horsepower, or fifteen times as much as in the first case. His assistants consisted of four warrant machinists, all practical men, but not one of them a man capable of achieving command-rank in engineering, and not one of them, of course, a graduate of Annapolis. This single comparison is a sufficient index as to the way things have been running in the engineering side of the navy during the past few years.

Give us engineers, and that right away!

ABSTRACTS FROM RULES AND REGULATIONS OF THE GREAT LAKES REGISTER.

EDITION OF 1904.

ARRANGED BY HARRISON S. TAFT.

(Continued.)

36. Spacing of Rivets.

DIAS.

1. Center of rivets from edge of plate or angle bar..... 1½

2. Butts of the shell plating. All butt straps..... 3½

3. Longitudinal seams or laps of the shell plating; of the deck plating; of the tank-top plating; of all watertight bulkheads; and of all other watertight work..... { Single riveted.. 3½ / Double " .. 4

4. Beam knees to beams and frames; tank-top frame and web-frame bracket plates; keelson angle bars to a flat-plate keel; rudder rivets..... 5

5. Bar keels; stems; stern posts (zigzag fashion)..... 5
Center to center of rows..... 3

6. Frames to reverse bars; angle bars to hold stringers; water-bottom longitudinals; steel decks and stringers to beams; shell plating to frames..... 7

7. The third row of a treble-riveted butt strap and the fourth row of a quadruple-riveted butt strap may be spaced 1 1-2 times the spacing of the other rows.

8. The spacing of rivets in each row of an overlapped butt must be the same.

9. When the side keelsons are fitted with treble-riveted double butt straps, the spacing of the third row may be twice that of the other two rows.

10. When the width of a quadruple-riveted butt strap exceeds the frame spacing, the fourth row which passes through the frame can be spaced 1 1-2 times the spacing of the other rows.

TABLE 7.—GREAT LAKES REGISTER. WIDTH OF BUTT LAPS AND BUTT STRAPS. SPACING OF RIVETS.

	Weight of Plate in Lbs.	Diametral Pitch.	10 to 12½	15 to 20	22½ to 25	27½ to 32½	35 to 40
	Diameter of Rivets for Plate and Angles. Inches.		⅝	¾	⅞	1	1⅛
	Diameter of Rivets for Stems: Stern Posts: Bar Keels. See No. 5 below.		⅞	[a] 1 and 1⅛	1⅛	1¼	1¼
Width of:	Single riveted butt laps	....	....	....	....	....	....
	Double " " "	6½	4	5	5¾	6¾	....
	Treble " " "	....	6	7¾	8¾	10	11¾
	Quadruple " " "	....	....	10½	11¾	13¾	15½
	Double " " straps	....	8	10½	11¾	13¾	15
	Treble " " "	....	12½	15¾	17½	20½	23
	Quadruple " " "	....	....	22	24	27½	31½
	Single " edge laps	....	2¾	2¾	....	....	....
	Double " " "	6½	4	5	5¾	6¾	7¾
	Single " " strips	....	....	....	....	....	....
	Double " " "	....	....	....	....	....	....
Spacing of rivets.	1.—Center of rivet from edge of plate or angle bar	1½	1⅜	1⅜	1⅜	1½	1⅝
	2.—Butts of the shell plating. All butt straps	3½	2 3/16	2⅝	3 1/16	3½	3⅝
	3.—Longitudinal seams or laps of the shell, deck and tank top plating. All other watertight work { Single riveted	3½	2 1/16	2⅝	3 1/16	3½	3⅝
	{ Double "	4	2⅞	3	3½	4	4⅛
	4.—Beam knees; tank top frame bracket plates: Keelson angle bars to a flat plate keel: rudder rivets	5	3⅛	3¾	4⅜	5	5⅝
	5.—Bar keels; stems: stern posts. Zigzag	5	3⅛	3¾	4⅜	5	5⅝
	Center to center of rows	3	1⅞	2¼	2⅝	3	3⅜
	6.—Frames to reverse bars; angle bars to hold stringers; water bottom longitudinals; steel decks and stringers to deck beams; shell frame rivets	7	4⅜	5¼	6⅛	7	7⅞
Spacing of rivets. Oil tanks only.	1.—Longitudinal seams of the shell plating; butts and seams of the "crown deck" plating; butts and seams of all bulkheads made oiltight	3½	2 3/16	2⅝	3 1/16	3½	3 11/16
	2.—Oiltight bulkhead frame bars; corner angles and collars; bulkhead stiffeners to be caulked	4	2¾	3	3½	4	4½
	3.—Butts and seams of a center line bulkhead not made oiltight; deck beam knee brackets; all other brackets worked to maintain continuity of strength	4½	2 13/16	⅞	3 15/16	4½	5 1/16
	4.—Bulkhead stiffeners not caulked	6	3¼	½	5¼	6	6¾
	5.—Frame and deck beam rivets	6½	4 1/16	4⅜	5 11/16	6⅝	7 5/16
	6.—Single frame bars at web frames. Zigzag	7	4⅜	5¼	6⅛	7	7⅞

[a] 15 and 17½ lbs. = 1" rivet. 20 lbs. = 1⅛" rivet.

PART II.

OIL VESSELS.

37. General.

1. The oil should go to the skin of the ship. When double bottoms are adopted said spaces must be well ventilated.

2. An oiltight longitudinal center-line bulkhead should be fitted in all vessels carrying an oil cargo. Said bulkhead is to extend from the keel to the top of the expansion trunk.

TABLE 8.—RIVETING SCHEDULE FOR BUTT STRAPS.

LENGTH OF VESSELS.

72	Depth.	5	6	7
	Flat plate keel and garboards	T R—$\frac{3}{4}$ L	T R—$\frac{3}{4}$ L	T R—$\frac{3}{4}$ L
	Bottom and side plating	D R—T	D R—T	D R—T
	Bilge plating	T R—$\frac{1}{2}$ L	D R—T	D R—T
	Sheer strake; stringers and ties	T R—$\frac{1}{2}$ L	D R—T	D R—T
	Center vertical keelson	T R—$\frac{1}{2}$ L	D R—T	D R—T
	Side keelsons	D R—T	D R—T	D R—T

96	Depth.	6	7	8
	Flat plate keel and garboards	T R—$\frac{3}{4}$ L	T R—$\frac{3}{4}$ L	T R—$\frac{3}{4}$ L
	Bottom and side plating	D R—T	D R—T	D R—T
	Bilge plating	T R—$\frac{1}{2}$ L	D R—T	D R—T
	Sheer strake; stringers and ties	T R—$\frac{1}{2}$ L	D R—T	D R—T
	Center vertical keelson	T R—$\frac{1}{2}$ L	D R—T	D R—T
	Side keelsons	D R—T	D R—T	D R—T

120	Depth.	8	9	10
	Flat plate keel and garboards	T R—T	T R—T	T R—$\frac{3}{4}$ L
	Bottom and side plating	D R—T	D R—T	D R—T
	Bilge plating	T R—$\frac{1}{2}$ L	T R—$\frac{1}{2}$ L	D R—T
	Sheer strake; stringers and ties	T R—$\frac{1}{2}$ L	T R—$\frac{1}{2}$ L	D R—T
	Center vertical keelson	T R—$\frac{1}{2}$ L	T R—$\frac{1}{2}$ L	D R—T
	Side keelsons	D R—T	D R—T	D R—T

144	Depth.	9	11	13
	Flat plate keel and garboard	T R—T	T R—T	T R—T
	Bottom and side plating	D R—T	D R—T	D R—T
	Bilge plating	T R—$\frac{1}{2}$ L	T R—$\frac{1}{2}$ L	T R—$\frac{1}{2}$ L
	Sheer strake; stringers and ties	T R—$\frac{1}{2}$ L	T R—$\frac{1}{2}$ L	T R—$\frac{1}{2}$ L
	Center vertical keelson	T R—$\frac{1}{2}$ L	T R—$\frac{1}{2}$ L	T R—$\frac{1}{2}$ L
	Side keelsons	D R—T	D R—T	D R—T

168	Depth.	11	12	14
	Flat plate keel and garboards	T R—T	T R—T	T R—T
	Bottom and side plating	D R—T	D R—T	D R—T
	Bilge plating	T R—$\frac{1}{2}$ L	T R—$\frac{1}{2}$ L	T R—$\frac{1}{2}$ L
	Sheer strake; stringers and ties	T R—$\frac{1}{2}$ L	T R—$\frac{1}{2}$ L	T R—$\frac{1}{2}$ L
	Center vertical keelson	T R—$\frac{1}{2}$ L	T R—$\frac{1}{2}$ L	T R—$\frac{1}{2}$ L
	Side keelsons	T R—$\frac{1}{2}$ L	D R—T	D R—T

192	Depth.	12	14	16
	Flat plate keel and garboards	T R—T	T R—T	T R—T
	Bottom and side plating	D R—T	D R—T	D R—T
	Bilge plating	T R—$\frac{1}{2}$ L	T R—$\frac{1}{2}$ L	T R—$\frac{1}{2}$ L
	Sheer strake; stringers and ties	T R—$\frac{1}{2}$ L	T R—$\frac{1}{2}$ L	T R—$\frac{1}{2}$ L
	Center vertical keelson	T R—$\frac{1}{2}$ L	T R—$\frac{1}{2}$ L	T R—$\frac{1}{2}$ L
	Side keelsons	T R—$\frac{1}{2}$ L	D R—T	D R—T

216	Depth.	14	16	18
	Flat plate keel and garboards	T R—T	T R—T	T R—T
	Bottom and side plating	T R—$\frac{1}{2}$ L	D R—T	D R—T
	Bilge plating	T R—$\frac{1}{2}$ L	T R—$\frac{1}{2}$ L	T R—$\frac{1}{2}$ L
	Sheer strake; stringers and ties	T R—T	T R—$\frac{1}{2}$ L	T R—$\frac{1}{2}$ L
	Center vertical keelson	T R—$\frac{1}{2}$ L	T R—$\frac{1}{2}$ L	T R—$\frac{1}{2}$ L
	Side keelsons	T R—$\frac{1}{2}$ L	D R—T	D R—T

240	Depth.	15	17	20
	Flat plate keel and garboards	T R—T	T R—T	T R—T
	Bottom and side plating	T R—$\frac{1}{2}$ L	D R—T	D R—T
	Bilge plating	T R—$\frac{1}{2}$ L	T R—$\frac{1}{2}$ L	T R—$\frac{1}{2}$ L
	Sheer strake; stringers and ties	T R—T	T R—T	T R—$\frac{1}{2}$ L
	Center vertical keelson	T R—$\frac{1}{2}$ L	T R—$\frac{1}{2}$ L	T R—$\frac{1}{2}$ L
	Side keelsons	T R—$\frac{1}{2}$ L	D R—T	D R—T

264	Depth.	17	19	22
	Flat plate keel and garboards	T R—T	T R—T	T R—T
	Bottom and side plating	T R—$\frac{1}{2}$ L	T R—$\frac{1}{2}$ L	D R—T
	Bilge plating	T R—T	T R—$\frac{1}{2}$ L	T R—$\frac{1}{2}$ L
	Sheer strake; stringers and ties	a. T R—$\frac{1}{2}$ L	T R—T	T R—$\frac{1}{2}$ L
	Center vertical keelson	T R—T	T R—$\frac{1}{2}$ L	T R—$\frac{1}{2}$ L
	Side keelson	a. T R—$\frac{1}{2}$ L	T R—$\frac{1}{2}$ L	D R—T

288	Depth.	18	21	24
	Flat plate keel and garboards	T R—T	T R—T	T R—T
	Bottom and side plating	T R—$\frac{1}{2}$ L	T R—$\frac{1}{2}$ L	D R—T
	Bilge plating	T R—T	T R—$\frac{1}{2}$ L	T R—$\frac{1}{2}$ L
	Sheer strake; stringers and ties	a. T R—$\frac{1}{2}$ L	a. T R—$\frac{1}{2}$ L	T R—T
	Center vertical keelson	T R—T	T R—T	T R—$\frac{1}{2}$ L
	Side keelsons	a. T R—$\frac{1}{2}$ L	a. T R—$\frac{1}{2}$ L	a. T R—$\frac{1}{2}$ L

LENGTH OF VESSELS.

312	Depth.	20	23	26
	Flat plate keel and garboards	T R—T	T R—T	T R—T
	Bottom and side plating	T R—$\frac{1}{2}$ L	T R—$\frac{1}{2}$ L	T R—$\frac{1}{2}$ L
	Bilge plating	T R—T	T R—T	T R—$\frac{1}{2}$ L
	Sheer strake; stringers and ties	T R—$\frac{1}{2}$ L	T R—$\frac{1}{2}$ L	T R—$\frac{1}{2}$ L
	Center vertical keelson	T R—T	T R—T	T R—$\frac{1}{2}$ L
	Side keelsons	T R—$\frac{1}{2}$ L	T R—$\frac{1}{2}$ L	T R—$\frac{1}{2}$ L

336	Depth.	21	25	28
	Flat plate keel and garboards	T R—T	T R—T	T R—T
	Bottom and side plating	T R—$\frac{1}{2}$ L	T R—$\frac{1}{2}$ L	T R—$\frac{1}{2}$ L
	Bilge plating	T R—T	T R—T	T R—$\frac{1}{2}$ L
	Sheer strake; stringers and ties	T R—$\frac{1}{2}$ L	T R—$\frac{1}{2}$ L	T R—$\frac{1}{2}$ L
	Center vertical keelson	T R—T	T R—T	T R—T
	Side keelsons	T R—$\frac{1}{2}$ L	T R—$\frac{1}{2}$ L	T R—$\frac{1}{2}$ L

360	Depth.	23	28	30
	Flat plate keel and garboards	T R—T	T R—T	T R—T
	Bottom and side plating	T R—T	T R—$\frac{1}{2}$ L	T R—$\frac{1}{2}$ L
	Bilge plating	T R—T	T R—T	T R—$\frac{1}{2}$ L
	Sheer strake; stringers and ties	T R—$\frac{1}{2}$ L	T R—$\frac{1}{2}$ L	T R—$\frac{1}{2}$ L
	Center vertical keelson	T R—T	T R—T	T R—T
	Side keelsons	T R—$\frac{1}{2}$ L	T R—$\frac{1}{2}$ L	T R—$\frac{1}{2}$ L

384	Depth.	24	26	32
	Flat plate keel and garboards	T R—T	T R—T	T R—T
	Bottom and side plating	T R—T	T R—$\frac{1}{2}$ L	T R—$\frac{3}{4}$ L
	Bilge plating	T R—T	T R—T	T R—$\frac{3}{4}$ L
	Sheer strake; stringers and ties	T R—T	T R—$\frac{1}{2}$ L	T R—$\frac{1}{2}$ L
	Center vertical keelson	T R—T	T R—T	T R—T
	Side keelsons	T R—$\frac{1}{2}$ L	T R—$\frac{1}{2}$ L	T R—$\frac{3}{4}$ L

408	Depth.	26	31	34
	Flat plate keel and garboards	T R—T	T R—T	T R—T
	Bottom and side plating	T R—T	T R—T	T R—$\frac{3}{4}$ L
	Bilge plating	T R—T	T R—T	T R—T
	Sheer strake	T R—T	T R—T	T R—$\frac{3}{4}$ L
	Stringers and ties	Quad—$\frac{1}{2}$ L	Quad—$\frac{1}{2}$ L	T R—$\frac{3}{4}$ L
	Center vertical and side keelsons	T R—T	T R—T	T R—T

432	Depth.	27	32	36
	Flat plate keel and garboards	Quad—$\frac{1}{2}$ L	T R—T	T R—T
	Bottom and side plating	T R—T	T R—T	T R—T
	Bilge plating	Quad—$\frac{1}{2}$ L	T R—T	T R—T
	Sheer strake	Quad—$\frac{1}{2}$ L	T R—T	T R—T
	Stringers and ties	Quad—$\frac{1}{2}$ L	Quad—$\frac{1}{2}$ L	T R—T
	Center vertical and side keelsons	T R—T	T R—T	T R—T

456	Depth.	28	32	36
	Flat plate keel and garboards	Quad—$\frac{1}{2}$ L	Quad—$\frac{1}{2}$ L	T R—T
	Bottom and side plating	T R—T	T R—T	T R—T
	Bilge plating	Quad—$\frac{1}{2}$ L	T R—T	T R—T
	Sheer strake	Quad—$\frac{1}{2}$ L	Quad—$\frac{1}{2}$ L	T R—T
	Stringers and ties	Quad—$\frac{1}{2}$ L	Quad—$\frac{1}{2}$ L	Quad—$\frac{1}{2}$ L
	Center vertical and side keelsons	T R—T	T R—T	T R—T

480	Depth.	30	33	36
	Flat plate keel and garboards	Quad—$\frac{1}{2}$ L	Quad—$\frac{1}{2}$ L	T R—T
	Bottom and side plating	T R—T	T R—T	T R—T
	Bilge plating	Quad—$\frac{1}{2}$ L	Quad—$\frac{1}{2}$ L	Quad—$\frac{1}{2}$ L
	Sheer strake	Quad—$\frac{1}{2}$ L	Quad—$\frac{1}{2}$ L	Quad—$\frac{1}{2}$ L
	Stringers and ties	Quad—$\frac{1}{2}$ L	Quad—$\frac{1}{2}$ L	Quad—$\frac{1}{2}$ L
	Center vertical and side keelsons	T R—T	T R—T	T R—T

504	Depth	30	33	36
	Flat plate keel and garboards	Quad—$\frac{1}{2}$ L	Quad—$\frac{1}{2}$ L	Quad—$\frac{1}{2}$ L
	Bottom and side plating	T R—T	T R—T	T R—T
	Bilge plating	Quad—$\frac{1}{2}$ L	Quad—$\frac{1}{2}$ L	Quad—$\frac{1}{2}$ L
	Sheer strake	Quad—$\frac{1}{2}$ L	Quad—$\frac{1}{2}$ L	Quad—$\frac{1}{2}$ L
	Stringers and ties	Quad—$\frac{1}{2}$ L	Quad—$\frac{1}{2}$ L	Quad—$\frac{1}{2}$ L
	Center vertical and side keelsons	T R—T	T R—T	T R—T

1. Tank top center line and margin strakes plates are to be double riveted throughout in all cases.
2. Double butt straps are to be fitted to the center vertical keelson in all cases.
3. Double butt straps are to be fitted to the sheer strake, to the stringers and ties, and to the side keelsons in all vessels of 312 feet or more in length. Also as indicated below.

a. Double butt straps D R — T = double riveted throughout. T R — T = treble riveted throughout. T R — $\frac{1}{2}$ L = treble riveted for $\frac{1}{2}$ length amidships. R — $\frac{3}{4}$ L = treble riveted for $\frac{3}{4}$ length amidships. Quad — $\frac{1}{2}$ L = quadruple riveted for $\frac{1}{2}$ length amidships. Quad — $\frac{3}{4}$ L = quadruple riveted for $\frac{3}{4}$ length amidships.

3. The fore-and-aft dimension of each oil tank in a steamer should not exceed 28 feet.

4. An expansion trunk must be fitted to each and every oil tank. Said expansion trunks are to extend above the "crown deck," having a capacity of not less than 6 per cent. of that of the corresponding oil tank to which they are fitted.

5. There must be a cofferdam at each end of the spaces devoted to an oil cargo, extending the entire breadth of the ship. Said cofferdams are to be at least two frame spaces wide, and are to extend to the top of the expansion trunk.

6. Each compartment must be tested by a head of water 11 feet above the crown of the tank, or 4 feet above the expansion trunk hatch covers.

TABLE 9.—RIVETING SCHEDULE FOR BUTT LAPS.

LENGTH OF VESSELS.

72	Depth.	5	6	7
	Garboards	T R—T	T R—T	T R — ¾ L
	Bottom and side plating	D R—T	D R—T	D R—T
	Bilge plating	T R—¾ L	T R—½ L	D R—T
	Sheer strake; stringers and ties	T R—¾ L	T R—½ L	D R—T
	Center vertical keelson	T R—¾ L	T R—½ L	T R—½ L
	Side keelsons	T R—½ L	D R—T	D R—T
	Tank top center and margin plates	D R—T	D R—T	D R—T

96	Depth.	6	7	8
	Garboards	T R—T	T R—T	T R—¾ L
	Bottom and side plating	D R—T	D R—T	D R—T
	Bilge plating	T R—¾ L	T R—½ L	D R—T
	Sheer strake; stringers and ties	T R—¾ L	T R—½ L	D R—T
	Center vertical keelson	T R—¾ L	T R—½ L	T R—½ L
	Side keelsons	T R—½ L	D R—T	D R—T
	Tank top center and margin plates	D R—T	D R—T	D R—T

120	Depth.	8	9	10
	Garboards	T R—T	T R—T	T R—¾ L
	Bottom and side plating	D R—T	D R—T	D R—T
	Bilge plating	T R—T	T R—½ L	T R—½ L
	Sheer strake; stringers and ties	T R—¾ L	T R—¾ L	T R—¾ L
	Center vertical keelson	T R—¾ L	T R—¾ L	T R—¾ L
	Side keelsons	T R—½ L	T R—½ L	D R—T
	Tank top center and margin plates	D R—T	D R—T	D R—T

144	Depth.	9	11	13
	Garboards	T R—T	T R—T	T R—T
	Bottom and side plating	D R—T	D R—T	D R—T
	Bilge plating	T R—T	T R—¾ L	T R—¾ L
	Sheer strake; stringers and ties	T R—T	T R—¾ L	T R—¾ L
	Center vertical keelson	T R—T	T R—¾ L	T R—¾ L
	Side keelsons	T R—¾ L	T R—½ L	D R—T
	Tank top center and margin plates	D R—T	D R—T	D R—T

168	Depth.	11	12	14
	Garboards	T R—T	T R—T	T R—T
	Bottom and side plating	D R—T	D R—T	D R—T
	Bilge plating	T R—T	T R—¾ L	T R—¾ L
	Sheer strake; stringers and ties	T R—T	T R—¾ L	T R—¾ L
	Center vertical keelson	T R—T	T R—¾ L	T R—¾ L
	Side keelsons	T R—¾ L	T R—½ L	T R—½ L
	Tank top center and margin plates	T R—½ L	D R—T	D R—T

192	Depth.	12	14	16
	Garboards	T R—T	T R—T	T R—T
	Bottom and side plating	T R—½ L	D R—T	D R—T
	Bilge plating	T R—T	T R—¾ L	T R—¾ L
	Sheer strake; stringers and ties	T R—T	T R—¾ L	T R—¾ L
	Center vertical keelson	T R—T	T R—¾ L	T R—¾ L
	Side keelsons	T R—¾ L	T R—½ L	T R—½ L
	Tank top center and margin plates	T R—½ L	T R—½ L	D R—T

216	Depth.	14	16	18
	Garboards	T R—T	T R—T	T R—T
	Bottom and side plating	T R—¾ L	T R—½ L	D R—T
	Bilge plating	T R—T	T R—¾ L	T R—¾ L
	Sheer strake; stringers and ties	T R—T	T R—T	T R—¾ L
	Center vertical keelson	T R—T	T R—¾ L	T R—¾ L
	Side keelsons	T R—¾ L	T R—½ L	T R—½ L
	Tank top center and margin plates	T R—½ L	T R—½ L	D R—T

240	Depth.	15	17	20
	Garboards	T R—T	T R—T	T R—T
	Bottom and side plating	T R—¾ L	T R—½ L	T R—½ L
	Bilge plating	T R—T	T R—¾ L	T R—¾ L
	Sheer strake; stringers and ties	T R—T	T R—T	T R—¾ L
	Center vertical keelson	T R—T	T R—T	T R—¾ L
	Side keelsons	T R—¾ L	T R—¾ L	T R—¾ L
	Tank top center and margin plates	T R—¾ L	T R—½ L	T R—½ L

264	Depth.	17	19	22
	Garboards	T R—T	T R—T	T R—T
	Bottom and side plating	T R—¾ L	T R—¾ L	T R—½ L
	Bilge plating	T R—T	T R—T	T R—¾ L
	Sheer strake; stringers and ties	T R—T	T R—T	T R—T
	Center vertical keelson	T R—T	T R—T	T R—¾ L
	Side keelsons	T R—¾ L	T R—¾ L	T R—½ L
	Tank top center and margin plates	T R—¾ L	T R—½ L	T R—½ L

288	Depth.	18	21	24
	Garboards	T R—T	T R—T	T R—T
	Bottom and side plating	T R—¾ L	T R—¾ L	T R—½ L
	Bilge plating	T R—T	T R—T	T R—¾ L
	Sheer strake; stringers and ties	T R—T	T R—T	T R—T
	Center vertical keelson	T R—T	T R—T	T R—T
	Side keelsons	T R—¾ L	T R—¾ L	T R—¾ L
	Tank top center and margin plates	T R—¾ L	T R—½ L	T R—½ L

LENGTH OF VESSELS.

312	Depth.	20	23	26
	Garboards	T R—T	T R—T	T R—T
	Bottom and side plating	T R—T	T R—¾ L	T R—½ L
	Bilge plating	Quad—¾ L	T R—T	T R—T
	Sheer strake; stringers and ties	Quad—¾ L	T R—T	T R—T
	Center vertical keelson	Quad—¾ L	T R—T	T R—T
	Side keelsons	T R—T	T R—¾ L	T R—¾ L
	Tank top center and margin plates	T R—¾ L	T R—¾ L	T R—½ L

336	Depth.	21	25	28
	Garboards	T R—T	T R—T	T R—T
	Bottom and side plating	T R—T	T R—T	T R—¾ L
	Bilge plating	Quad—¾ L	T R—T	T R—T
	Sheer strake; stringers and ties	Quad—¾ L	T R—T	T R—T
	Center vertical keelson	Quad—¾ L	T R—T	T R—¾ L
	Side keelsons	T R—T	T R—¾ L	T R—¾ L
	Tank top center and margin plates	T R—¾ L	T R—¾ L	T R—½ L

360	Depth.	23	26	30
	Garboards	Quad—½ L	T R—T	T R—T
	Bottom and side plating	T R—T	T R—T	T R—¾ L
	Bilge plating	Quad—½ L	Quad—½ L	T R—T
	Sheer strake; stringers and ties	Quad—½ L	Quad—½ L	T R—T
	Center vertical keelson	Quad—½ L	T R—T	T R—T
	Side keelsons	T R—T	T R—T	T R—¾ L
	Tank top center and margin plates	T R—T	T R—¾ L	T R—½ L

384	Depth.	24	28	32
	Garboards	Quad—½ L	T R—T	T R—T
	Bottom and side plating	T R—T	T R—T	T R—T
	Bilge plating	Quad—½ L	Quad—½ L	T R—T
	Sheer strake; stringers and ties	Quad—½ L	Quad—½ L	T R—T
	Center vertical keelson	Quad—½ L	Quad—½ L	T R—T
	Side keelsons	Quad—½ L	T R—T	T R—T
	Tank top center and margin plates	T R—T	T R—¾ L	T R—¾ L

408	Depth	26	31	34
	Garboards	Quad—½ L	Quad—½ L	T R—T
	Bottom and side plating	T R—T	T R—T	T R—T
	Bilge plating	Quad—½ L	Quad—½ L	T R—T
	Sheer strake; stringers and ties	Quad—½ L	Quad—½ L	T R—T
	Center vertical keelson	Quad—½ L	Quad—½ L	T R—T
	Side keelsons	Quad—½ L	Quad—½ L	T R—T
	Tank top center and margin plates	T R—T	T R—T	T R—T

432	Depth.	27	32	36
	Garboards	Quad—¾ L	Quad—½ L	T R—T
	Bottom and side plating	T R—T	T R—T	T R—T
	Bilge plating	Quad—¾ L	Quad—½ L	Quad—½ L
	Sheer strake; stringers and ties	Quad—¾ L	Quad—½ L	Quad—½ L
	Center vertical keelson	Quad—½ L	Quad—½ L	T R—T
	Side keelsons	Quad ½ L	Quad—½ L	T R—T
	Tank top center and margin plates	T R—T	T R—T	T R—T

456	Depth.	28	32	36
	Garboards	Quad—¾ L	Quad—½ L	Quad—½ L
	Bottom and side plating	Quad—½ L	T R—T	T R—T
	Bilge plating	Quad—¾ L	Quad—¾ L	Quad—½ L
	Sheer strake; stringers and ties	Quad—¾ L	Quad—¾ L	Quad—½ L
	Center vertical keelson	Quad—½ L	Quad—½ L	T R—T
	Side keelsons	Quad—½ L	Quad—½ L	T R—T
	Tank top center and margin plates	T R—T	T R—T	T R—T

480	Depth.	30	33	36
	Garboards	Quad—¾ L	Quad—½ L	Quad—½ L
	Bottom and side plating	Quad—½ L	T R—T	T R—T
	Bilge plating	Quad—T	Quad—¾ L	Quad—¾ L
	Sheer strake; stringers and ties	Quad—T	Quad—¾ L	Quad—¾ L
	Center vertical keelson	Quad—¾ L	Quad—½ L	Quad—½ L
	Side keelsons	Quad—¾ L	Quad—½ L	Quad—½ L
	Tank top center and margin plates	T R—T	T R—T	T R—T

504	Depth.	30	33	36
	Garboards	Quad—T	Quad—¾ L	Quad—¾ L
	Bottom and side plating	Quad—½ L	Quad—½ L	T R—T
	Bilge plating	Quad—T	Quad—T	Quad—¾ L
	Sheer strake; stringers and ties	Quad—T	Quad—T	Quad—¾ L
	Center vertical keelson	Quad—T	Quad—¾ L	Quad—½ L
	Side keelsons	Quad—½ L	Quad—½ L	Quad—½ L
	Tank top center and margin plates	T R—T	T R—T	T R—T

1. For flat plate keels, see Table 8.
D R — T = double riveted throughout.
T R — T = treble " "
Quad — T = quadruple " "
T R — ½ L = treble " for ½ length amidships.
T R — ¾ L = " " " ¾ " "
Quad — ½ L = quadruple " " ½ " "
Quad — ¾ L = " " " ¾ " "

7. The entrance to the shaft tunnel is to be from the main deck, at both ends of said tunnel.
8. Electric lights must be fitted throughout on the double-wire system.

38. Keels and Center-Line Keelsons.

1. KEELS.

(*a*) The flat plate type of keel should be adopted, said keel plates being 20 per cent. heavier than in ordinary

vessels. When a double plate keel is required, a single plate keel may be worked if the tabulated thickness is increased by 75 per cent.

(*b*) The width of said keel plates should be 1 1-2 times their width in ordinary vessels so as to provide for a secure attachment of the frames to said plates.

(*c*) It is recommended that said keel butts be overlapped. When straps are used they must be worked double.

2. CENTER-LINE KEELSONS.

The center-line keelson is to form the bottom strake of the center-line longitudinal bulkhead, and should be worked continuously all fore-and-aft. Said keelson is to be deep enough so as to have its lap with the plating above it clear of the floor brackets to said bulkhead. The lower keelson angles to a flat plate keel may be cut at an athwartship bulkhead, but such is not recommended. Said keelson should maintain its midship weight for 2-3 length amidships.

39. Frames.

1. The frames may be cut 9 inches short of the center-line keelson so as to allow a free flow for the oil to the pumps.

2. In two-deck vessels, when cut at the second-deck stringer, the frames between decks are to be secured to said stringer plate by large brackets, equal to the thickness of the frame flange to which they are attached, with at least a six-rivet connection to the frames and to the deck-angle clips.

3. Frame bars are to be worked single at all athwartship tank bulkheads.

40. Floor Plates.

1. Floor plates should be secured to the center-line keelson or bulkhead by angle clips of at least 3 inches by 3 inches, and by a bracket plate of the same weight as the floors. Said brackets are to be on each side 1 1-2 times the depth of midship floors and overlap onto the floors. If said brackets have a flanged diagonal edge, or a clip in lieu of same, they may be 2 1-2 pounds less in weight than otherwise.

2. When the frame numerical is 70 and above the angle clips securing the floors and their bracket plates to the center-line keelson or bulkhead must be of such a size as to allow of double zigzag riveting in both flanges.

3. The floor plates are to be worked at the bilge as in ordinary vessels; or bracket plates may be fitted at said point. When the frame numerical is below 50 said brackets need be fitted to alternate frames only.

4. Limber holes are to be cut in all floors as in ordinary vessels.

41. Reverse Frames.

1. When compound frames are adopted all the reverse frames must extend at least to the "crown deck."

2. With bulb angle frames reverse clips must be fitted to the frames in way of all side stringers; having a three-rivet connection to said frames, but a two-rivet connection to the stringer angle bar when the stringer plates are not supported by knee brackets at alternate frames.

42. Floor Side Keelsons.

1. When said keelson angles are cut at a bulkhead they are to be securely bracketed to said bulkhead; the diagonal edge of the brackets being flanged when the keelson angles are 6 by 4 inches or above.

TABLE 10.—TYPE OF FLOOR KEELSONS.

Molded Beam. Feet.	28	30	34	36	38	40 and 41	42 and 43	44
Number of keelsons.....	2	2	2	2	2	2	2	2
Type of first keelson.....	D A+I P	D A+I P	D A+I P	D A+I P	D A+I P	D A+I P+B A	D A+I P+K P T A	D A+I P+K P T A
" " second keelson.....	D A	D A	D A	D A+B A	D A+I P+B A	D A+I P+B A	D A+I P+B A	D A+I P+K P T A

D A = double angles; I P = intercostal plate; B A = bulb angle; K P T A = keelson plate with double top angles.
Keelson plate to be in depth twice the broader flange of the keelson angles.
Bulb angles to be of the size required for second deck beams.

43. Web Frames.

1. The web-frame plates are to equal the thickness of the standing flange of the frame bar to which they are attached, and be in width not less than four times the depth of said flange.

TABLE 11.—ARRANGEMENT OF WEB FRAMES AND SIDE STRINGERS.

Depth in Feet to the Upper Deck.	Web Frames. Width.	Weight.	Spacing.	Number of Side Stringers and Bulkhead Horizontal Stiffeners.	Type of Vessel.
	Inches.	Lbs.	Frames.		
14	16	12½	6	2	One-deck vessels.
16	16	13¾	6	2	" " "
18	18	15	6	3	" " "
20	18	17½	6	2	" " " with hold beams.
22	20	17½	6	2	" " " " " "
24	20	17½	6	2	Two " "
26	22	17½	5	3	" " "
28	22	18¾	5	3	" " "
30	22	18¾	5	2	" " " with hold beams.
32	24	20	5	2	Three " "

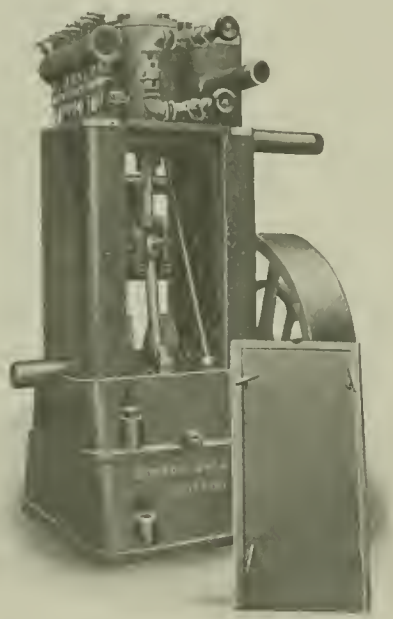
When strong hold beams are required they must be fitted in way of each web frame, and the side stringer in way thereof is to be increased to the width required for lower deck stringers.

ENGINEERING SPECIALTIES.

The Boston Steam Engine.

Carefully designed to fulfill any work to which it may be put, this engine combines the neatness and freedom from dirt of the cast-iron-frame engine with the lightness and accessibility of the open type. All of the working parts are inclosed in a double casing of Russia iron. The inside casing takes all the splash of the oil, leaving the outside casing always clean. This casing is made in four parts, the front and back being fastened with catches which allow of instant removal for any ordinary inspection, while the end pieces can be taken off by the removal of a few machine screws if a thorough overhauling should be necessary.

The pistons are steel castings and the crossheads are steel or phosphor-bronze. The connecting rods are steel forgings with composition boxes lined with white metal. The valve gear, with exception of eccentric and governor weight, is of steel or composition. The crank shaft is of forged steel carefully balanced with counterweights of cast iron. The frame is of rolled steel with diagonal bracing to prevent vibration. The governor is of



the inertia type, thus insuring the closest regulation. The double ported piston valves are placed as close to the cylinder as possible, thus cutting down the clearance spaces and steam consumption to the smallest amount. The wearing surfaces are of ample proportions to insure cool running at the highest speeds. Lubrication is secured in the smaller sizes by multiple-feed oil tanks and gravity feed, but in the larger sizes oil pumps for forced lubrication are fitted.

For electric generating sets these engines are especially suitable on account of their high speed and cleanliness. The entire inclosing of the working parts permits the engine to be almost flooded with oil without any finding its way into the dynamo. For these sets an extended base is furnished, which supports both engine and dynamo, thus making the whole plant self-contained. For fans or centrifugal pumps, especially for use on shipboard, these engines should commend themselves to all users, not only on account of their lightness, compactness and accessibility, but because dust and ashes from the fireroom will always be excluded from the working parts, which may be covered with oil without making a dirty engine room.

The engines are made by the Boston Steam Engine Company in eight sizes, ranging from 1¾ to 32 horsepower, and running at from 1,000 to 400 revolutions per minute, respectively.

Rich Drills and Chucks.

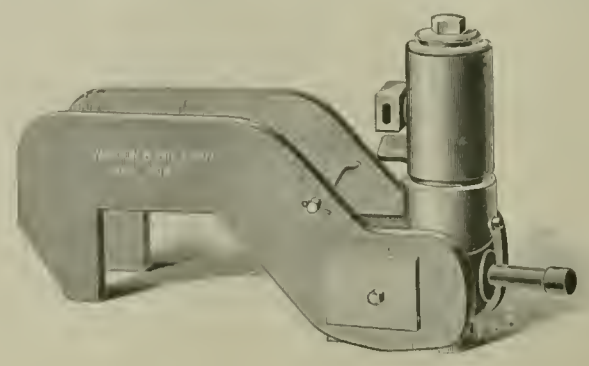
The introduction of high-grade tool steels, known as high-speed or air-hardening steels, has revolutionized machine-shop practice. Cutting speeds have been greatly increased, and the capacities of machine tools have been more than doubled. Most machine-shop drilling, however, has been done with twist drills, so manufactured that when made of high-grade tool steel they are very expensive; and the shape of the drill, involving as it does a shank, necessitates the waste of much expensive material in a part of the drill which is practically useless so far as cutting is concerned, while the danger of breaking and thereby spoiling an expensive tool discourages its wide use. The Rich flat drill is a device designed to fill the demand for a cheap drill capable of operating at high speeds and heavy feeds in hard and tough materials. It is made of a rolled bar of very carefully selected high-speed tool steel of the highest quality. Suitable lengths are cut from the bar and very carefully tempered throughout their entire lengths, and ground true to form.

The chuck has been designed as a drill-press attachment for holding the flat drill dead true and absolutely firm by adjustable jaws, which are set up by the thrust block within the barrel. The position of this thrust block is regulated by the external adjusting nut, by which compensation for the wearing of the point by grinding may be made. These drills and chucks are manufactured by the George R. Rich Manufacturing Company, Buchanan, Mich.

Some of the advantages claimed for these drills and chucks are that they may be used at heavy feeds and high speeds; will drill the hardest kind of material; retain a sharp cutting edge much longer than the ordinary drill, and when they must be sharpened the grinding is easy; and the drills are tempered throughout, and can be used to within two inches of the end. At the New York Navy Yard ten holes were drilled in the armor-plate turrets on the battleship *Connecticut* with a 1¼-inch flat drill, while eight twist drills were used without finishing one hole. In an endurance test at one of the Carnegie steel rail mills, a set of these flat drills each drilled 1,600 holes one inch in diameter in 80-pound rails without being reground.

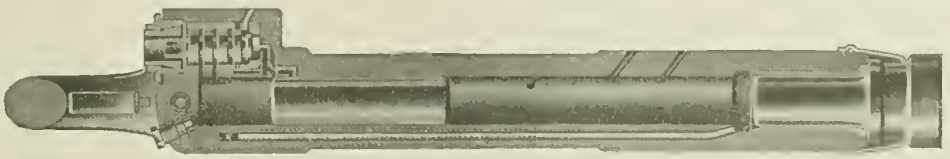
A Coupling-Bolt Forcer.

For the purpose of forcing in or out the coupling bolts on flanges of steamship shafts, the Watson-Stillman Company, of New York, has placed upon the market a number of instruments of varying design and capacities to suit the special requirements of each case. There are three designs, the smallest of which has a frame in one piece and acts much like a hydraulic punch, except that there is no return action to the ram. It can exert a force equivalent to fifteen tons. Another type has a movable cylinder with stationary ram, and has been used to some extent



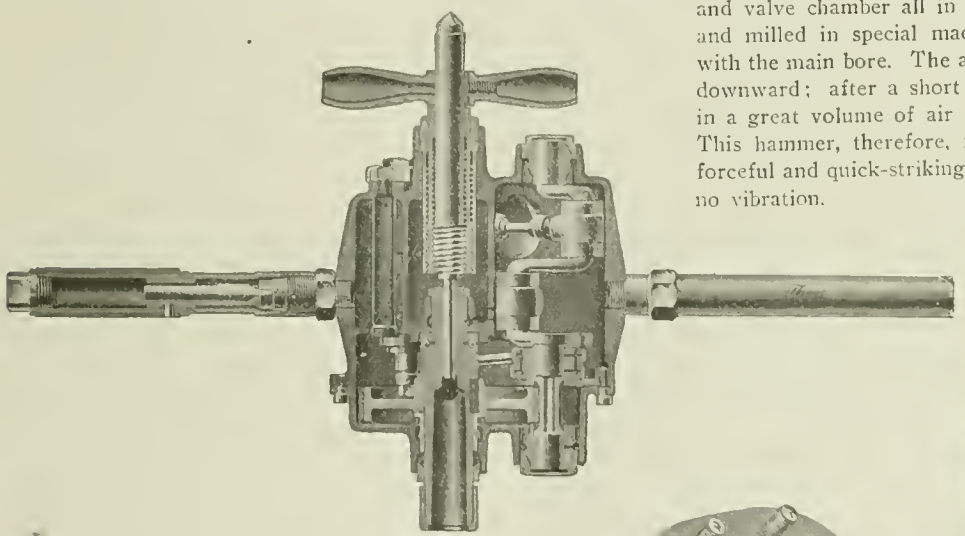
for the purpose above specified on ships of the United States Navy. It can be used in close proximity to a bulkhead. The force applied varies from fifteen to forty tons, according to the dimensions selected.

The third type, which is the one we illustrate, is the same in action as the others, but is larger and more powerful The ram is movable and has a stroke of three inches. The sizes vary from 25 to 40 tons in power, and in some of the designs an arrangement is made whereby the ram can be drawn back into position after having forced out the bolt.



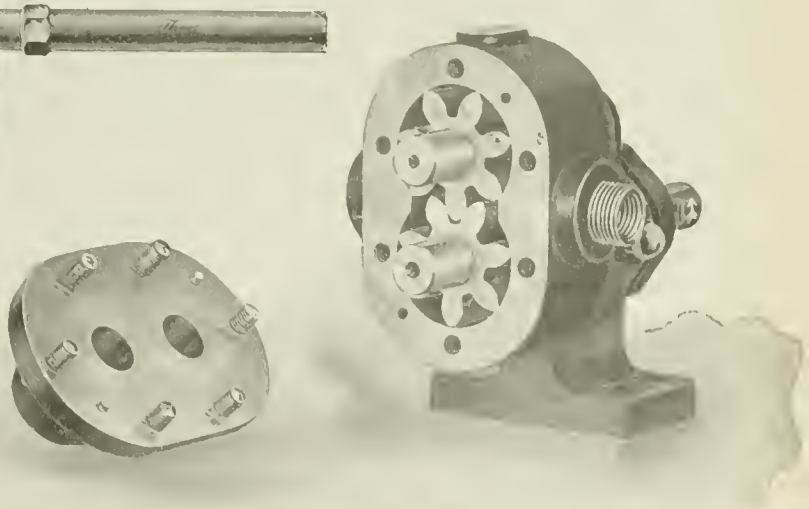
Thor Pneumatic Tools.

We illustrate herewith a sectional view of the non-reversible drill made by the Independent Pneumatic Tool Company, of Chicago, which differs in a number of ways from other drills on the market, being of the reciprocating piston type, and having four single-acting cylinders placed in the body of the machine.



The admission of air to the cylinders is controlled by means of Corliss valves placed immediately adjacent to the cylinder. The air is magazined and controlled within three-eighths of an inch or less of the cylinders, and when released acts practically instantaneously upon the pistons. The valves are operated from one double eccentric, which is provided with an individual bearing independent of the crank shaft or any other working part of the motor, and is driven from the crank shaft by means of a spur gear. The bearings of the crank shaft are placed close to the crank, which makes a saving in the total length of the motor equal to the length of the eccentric. One of the new features is the telescopic feed. The feed rod consists of an externally-threaded rod which works through an internally-threaded sleeve to the extreme limit, and then the sleeve also works out of the motor an equal distance, thus giving a feed practically double that which could be obtained with an ordinary single feed rod. The reversible drills have the same general features, with the addition of a device for admitting air to the cylinders so as to cause the drills to rotate in the opposite direction, which is desirable in reaming, tapping, rolling flues and wood boring. This is done by sending the air through the exhaust port into the valve chamber and thence into the cylinders, instead of by the usual route. This result is accomplished by means of a simple two-way valve which is placed in the admission chamber at the inner edge of the inlet pipe.

The Thor hammers are of two general types, the duplex valve chipping and calking hammer, and the one-piece auxiliary valve long-stroke riveting hammer. The main novelty and greatest advantage of the latter lies in the construction of handle, barrel and valve chamber all in one solid piece of steel forging, bored and milled in special machinery. The main valve lies parallel with the main bore. The auxiliary valve lightly starts the plunger downward; after a short travel the main valve opens and lets in a great volume of air direct and pretty close to the plunger. This hammer, therefore, from a gentle start gets an extremely forceful and quick-striking blow and quick return, with practically no vibration.



A Rotary Circulating Pump.

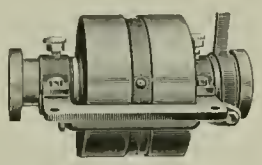
A reliable circulating pump is one of the essential features of all water-jacketed gas or gasoline engines and the more simple, compact and durable it is, the less liability is there of its getting out of order and impairing the efficiency of the engine. To meet this demand the Brown & Sharpe Manufacturing Company, Providence, R. I., has recently placed upon the market a bronze pump that is especially well adapted to this purpose.

The pump is simple in construction, the principal mechanism being a pair of gears that run together in a tight case, there being no valves to leak or get out of order. Either side of the pump can be used for suction, thus allowing it to be run in either direction. The driving shaft is ⅝ of an inch in diameter,

extends 1⅞ inches beyond the supporting bracket, and has a flat for set-screw. A suitable stuffing box is provided for the outer bearing of the shaft. The supporting bracket has four holes ⅝ of an inch in diameter. A sprocket wheel and chain are usually employed for operating the pump, which is made in two sizes, weighing 7 and 20 pounds respectively, and delivering from 1 to 8 and from 8 to 40 quarts per minute against heads up to 20 feet, the amount being dependent upon number of revolutions (100 to 500).

A Reversing Clutch for Marine Engines.

A clutch which can be used in connection with any marine engine and propeller has the gears always in mesh, with the two ends of the shaft joined together by the friction sleeves, so



that when the engine is going ahead the propeller is operated by the after cone, and there is no relative motion in the clutch gears. For reversing, the other cone is thrown into action, and is held in position by the thrust of the propeller, thus obviating undue friction on the shaft and the yoke of the lever. In this position the gears operate in the usual manner to give the propeller rotation in a direction the reverse of the preceding. The clutch is fitted with three sets of thrust ball bearings, with a minimum amount of friction. It is placed upon the market by the Holliday Manufacturing and Engineering Company, of Chicago.

TECHNICAL PUBLICATIONS.

Houseboats and Houseboating. Edited by Albert Bradlee Hunt. Size 9½ by 12 inches. Pages 216 + xv. Illustrations 198. New York: Forest and Stream Publishing Company, 1905. Price $3.00.

This is by all odds the most complete and valuable book on the subject of houseboats which has come to our attention. It is devoted mainly to houseboating as it exists in the United States, but one considerable chapter is taken up with houseboating in England, where the sport, if such it may be called, has attained probably a higher degree of perfection, and certainly a greater degree of popularity than is the case in the United States. The subject is taken up from all points of view, structural, decorative and that of mobility. Boats have been shown both by photographs and by accommodation plans and profiles which are propelled in the several cases by sails, by steam engines and by internal combustion motors, as well as barges having no propulsive power of their own, and depending for their mobility upon outside means of traction. A large number of boats of various classes, sizes and elaborateness are described in detail, with both interior and exterior views in great profusion, and the large variety of examples given is what makes the work so extremely valuable to anyone interested in the subject. While it may be said that the lines of a houseboat as such are of purely secondary consideration, because of the very low speed at which these boats always move, yet a number of cases will be found here where the lines are given. The last chapter, which consists of fifteen pages, is a description of the inside route from New York to Florida, giving distances in miles, and the general conditions to be met en route, together with lists of charts and a great variety of information of importance to anyone navigating over the course.

The book should have a ready acceptance at the hands of every one interested in the subject from the point of view of ownership or prospective ownership of a houseboat, while its value to those concerned in the design and construction of these craft must be very great, indeed.

Bureau Veritas: Rules for the Fitting-up of Motor Boats and Motors. Size 5¼ by 8¼. Pages 19. Published by Bureau Veritas, 8 Place de la Bourse, Paris, 1905.

This little pamphlet covers rules for the general use of constructors of motor boats and the machinery therefor, giving in considerable detail the requirements to be met in connection with the various devices used, and with regard to the installation of the motor into various types of boats.

Pocket Book of Mechanical Engineering. By Charles M. Sames, B. Sc. Size 4 by 6¾ inches. Pages 168. Bound in flexible leather. Published by the author, Jersey City, N. J., 1905. Price $1.50.

This is a condensed mechanical engineers' pocketbook, covering the same general scope of practice as with the larger and more elaborate books, but going far less into detail in that it gives only the most important and most generally used tables, data, formulas, etc. It has been compiled from information found in standard treatises and reference books, technical periodicals and various other sources, and is a first edition.

Gas, Gasoline and Oil Engines. By Gardner D. Hiscox. M. E., Size 6 by 9 inches. Pages 442; figures 351. New York: The Norman W. Henley Publishing Company, 1906. Price $2.50 net.

This is a very comprehensive and thoroughly modern treatise, taking up the subject from the American point of view. It goes fully into the construction, installation, operation and maintenance of engines of the types included under the heading, covering internal combustion motors for stationary, marine and automobile use. The illustrations are very complete and well chosen, giving details of construction, as well as diagrams and illustrations of every sort of device which is used by various makers for the operation of the motors.

Tabulated sizes of parts are given and considerable valuable information on testing plants for economy and for the power produced by the engines. To add to its value as a reference book, there is given a list of the leading gas and oil engine manufacturers in the United States and Canada; together with a 22-page list of United States patents on these engines, covering the period from 1875 to September 1, 1905, inclusive.

QUERIES AND ANSWERS.

All reasonable questions concerning marine engineering received from and signed by subscribers will be answered by the Editor in this column. All communications must bear the name and address of the writer.

Q. 311.—Please advise me what the requirements are for examination for license to run a steam plant in a pleasure launch of about 10 horsepower. A. L. H.

A.—The term "horsepower" does not enter into the question of granting licenses to engineers, special grades of license being based upon tonnage. A person may obtain a special license as an engineer of pleasure steamers of ten tons and under without regard to the horsepower of the engine, by simply satisfying the local inspectors that he is qualified for the said special license. There are no specified legal requirements for this class of license, the question of qualifications being a matter that is wholly within the discretion and judgment of the local inspectors to whom the person applies for license. If the steamer is more than ten tons, no matter whether the engine be a 2 horsepower or 100 horsepower, then the engineer must be licensed in accordance with Section 24, Rule V, General Rules and Regulations of the Steamboat Inspection Service, Department of Commerce and Labor.

Q. 312.—Do you think the present rule of rating horsepower is correct? For instance, I have a 3-cylinder, 4-cycle motor, 3⅝-inch bore, 4½ stroke, rated by the manufacturer as 10 horsepower at 900 revolutions. This motor would turn a 2-blade, 16-inch-diameter, 21-inch-pitch propeller 875 revolutions per minute. I tried a pair of blades 20 inches diameter 24-inch pitch and turned them 650 revolutions per minute, making a boat speed of 9 miles an hour, this speed rating the motor about 7.5 horsepower. Boat made about the same time as 16-inch 21-inch pitch, or 10 horsepower. I then tried a pair of blades 18 inches diameter, 27 inches pitch, and turned

them 590 per minute, or rating motor not 7 horsepower, and made 8 knots. It seems to me as though any motor with a certain bore, length of stroke and compression will give only a certain amount of power. This motor is in a hull 24 feet 10 inches long, 4 feet 6 inches beam at load waterline, 12 inches draft, widest beam three-fifths aft of bow. W. E. G.

A.—The fact that your motor in the second case turned the propeller 650 revolutions per minute only, in place of 875 in the first case, is in itself no definite indication that it was operating at only 7.5 horsepower in place of 10, because a great deal would depend upon the character of the indicator cards under the two conditions. You state that in the second case the speed of the boat was about the same as the first. This would have been the case had the power been the same in each case; or it would be the case if the power in the second instance were less than in the first, but the general efficiency of the propeller in itself and as adapted to the hull correspondingly greater. The third case seems to bear out this general line of reasoning.

Q. 313.—Would like you to give me a formula by which to calculate diameter, pitch and blade area for propellers for a twin-screw steamer of very blunt lines, length on waterline 166 feet, beam 40 feet; draft, aft 11 feet, forward 9 feet, when light, and average 16½ feet when loaded; indicated horsepower 800; revolutions 125 per minute. I find a number of formulas in Seaton, Kent, etc., but none applicable to twin screws for blunt boats. C. G. B.

A.—The question of the design of a propeller for a specific case of the unusual characteristics of the present one is not at all clearly defined, and a great deal of the design must necessarily depend upon experience with cases more or less similar to the one in hand. A formula found on page 263 of Durand's "Resistance and Propulsion of Ships" is:

$$(d')^2 = \frac{U}{(p'N')^3 \times (i\,k\,l\,m)}$$

where d' is the diameter of the propeller, expressed for convenience in units each of which is 10 feet, p' is the pitch of the propeller in the same units, N' is the number of tens of revolutions; i, k, l and m are coefficients depending respectively upon the form of blade, the slip of the propeller, the pitch ratio and the reaction between the propeller and the hull; U is the actual power delivered by the propeller upon the water, and in the present case would be probably not more than from 45 to 50 percent of the indicated horsepower of the engines. It should be noted that this latter term refers to the power on one shaft and not to the total power. Assuming a propulsive coefficient of 50 percent, the horsepower delivered by each propeller would be 200. If we, moreover, assume that the ship has a displacement of 2,500 tons, then with an admiralty coefficient of performance of 140, the speed would be 8.5 knots. Assuming from the bluntness of the lines that the propellers will work at a slip of about 30 percent, and taking a pitch ratio of 1.1, we find from tables on pages 253, 264 and 265 of the work above quoted values for i, k, l and m which are respectively 1.2, 0.214, 0.739 and 1.07; while the factor $(p'N')^3$ becomes 1.977 from the fact that $p\,N = \frac{8.5 \times 101.3}{1 - 0.30} = 1.255$.

Following these values through the formula first given, we find that $(d')^2 = 0.499$, whence $d = 7$ feet 1 inch, and $p = 7$ feet 9 inches.

It is more than likely that these figures would have to be very materially modified from experience with the wheel itself. They are not intended to give a solution of the problem as stated, but merely to show the manner by which such a solution may be obtained. Without more definite knowledge regarding the various characteristics of the hull, it would be out of the question to attempt any accurate quantitative solution.

Q. 314.—I wish to ask a question concerning the proper size of piston rod, at the smallest point, for a given diameter of cylinder, length of stroke, pressure and revolutions. Have looked in several books for a good and safe formula, but as yet have not seen one. Can you suggest a rule which is both practical and safe? J. M. F.

A.—The diameter of a piston rod would depend entirely upon the diameter of cylinder, length of stroke and pressure of steam, as the number of revolutions per minute would have no effect upon its determination. Formulas for taking care of such a problem are to be found in all working manuals of marine engineering. The one we give below is taken from page 163 of Seaton's "Manual of Marine Engineering." The piston rod may be assumed as fixed at the end at which it is joined to the piston, and loose at the crosshead end, because the crosshead would offer little resistance to bending. The formula is as follows:

$$P = \frac{2fS}{2 + 5a\frac{l^2}{d^2}}$$

where P = the load on the piston in pounds; l = the length of the piston rod; d, its diameter; a, a coefficient given as 1/3,000; S, the area of the piston rod section, and f the safe fiber stress to be allowed on the material, which may be stated to be 5,000 pounds per square inch. If we substitute for P its equivalent $p \times \frac{\pi D^2}{4}$, where p is the pressure per square inch on the piston when that pressure is a maximum, and D is the diameter of the piston; and further substitute the value above given for f, our formula becomes:

$$pD^2 = \frac{10{,}000d^2}{2 + \frac{l^2}{600d^2}}.$$

This is a formula involving biquadratics, as will be seen upon the working out of a specific case.

Let us take a cylinder with diameter 20 inches, length of piston rod 30 inches, and steam pressure 150 pounds per square inch; then the formula becomes:

$$60{,}000 = \frac{10{,}000d^2}{2 + \frac{900}{600d^2}}.$$

This formula readily reduces to $12 + \frac{9}{d^2} = d^2$, and the solution gives the value of d as about 3⅝ inches. With $f = 6{,}000$, d becomes 3¼ inches.

Q. 320.—Can you give me a rule for estimating the power necessary to drive a launch at a given speed?—say for boats from 15 to 75 feet length? J. P. L.

A.—The formula used for estimating the power necessary to drive a launch at a given speed is:

$$H = \frac{D^{\frac{2}{3}} \times V^3}{K},$$

where H is horsepower, D = displacement of the launch in tons of 2,240 pounds each, V = speed of the launch in knots, and K is a coefficient the value of which depends partly upon the size of the launch, partly upon the lines of the launch and the adaptation of the propeller to those lines. For a launch of easy lines, of considerable size and low speed, this constant may reach 225. For a high-speed launch of relatively small size it would probably be not greater than 100. Experience and practice are necessary for the determination of the coefficient to be used in each specific case, but it may be said that for cases where the form is average or easy and the speed is not excessive, the figure would be found usually from 150 to 180.

Q. 322.—What formula is used to determine the thickness of a boiler-shell plate for a given steam pressure? Please give formula to determine the pitch of rivets in seams, and if you know of any book that gives such formula, please mention. G. H.

A.—The formula for determining the thickness of boiler plate is:

$$t = \frac{pD}{2}.$$

This comes from a consideration of the fact that the steam pressure within the boiler tending to disrupt it is $p \times D \times L$, where p is the pressure in pounds per square inch, D is the diameter of the boiler in inches, and L the length in inches; on the other hand, the force tending to hold the shell together is $s \times 2t \times L$, where s is the safe fiber stress of the material in pounds per square inch, t is the thickness of the material in inches, and L, as before, the length of the boiler in inches.

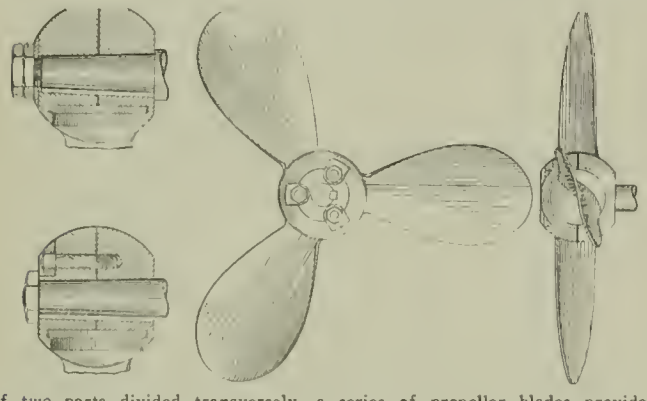
The diameter of rivets used comes from a consideration of the relative strength of the rivets against shearing off to the tensile strength of the part of the plate not cut away by the rivet holes. General practice makes the diameter of the rivet about 1.8 times the thickness of the plate; the pitch of the rivet for single riveting about 2½ times the diameter of the rivet; and for double riveting about 3½ times the diameter.

This information is contained in all works of marine engineering, particularly those concerned with design.

SELECTED MARINE PATENTS.

800,918. ADJUSTABLE PROPELLER. FRANKLIN G. HOBART, BELOIT, WIS., ASSIGNOR TO FAIRBANKS, MORSE & CO., CHICAGO, ILL.

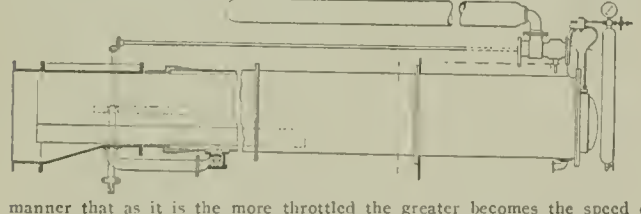
Claim.—1. An adjustable propeller comprising a clamping hub composed



of two parts divided transversely, a series of propeller blades provided with rotatable flanged shanks engaging undercut recesses in said hub, and means for tightening the two parts of the hub together to clamp said shanks in any desired position. Two claims.

801,792. BROADSIDE UNDER-WATER TORPEDO-LAUNCHING APPARATUS. ALBERT E. JONES, WEYMOUTH, ENGLAND, ASSIGNOR TO WHITEHEAD & CO., FIUME, AUSTRIA.

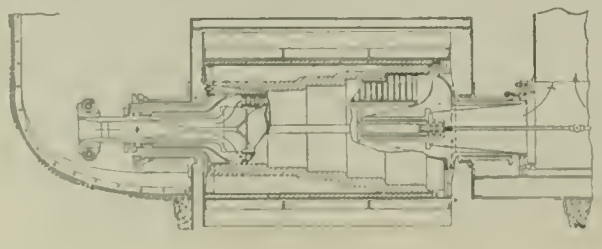
Abstract.—According to the present invention the initial pressure of the fluid used for pushing out the torpedo-casing and which is sufficient to impart to the torpedo a predetermined speed in the release position is left unaltered; but the admission of the fluid under pressure to the tube in rear of the piston operating the torpedo is automatically governed in such



a manner that as it is the more throttled the greater becomes the speed of the torpedo-casing. Thus the torpedo-casing and the torpedo will arrive in the release position of the latter always with one and the same speed regardless of the speed of the ship and any other circumstances that might affect the movement of the torpedo-casing. Immediately after the torpedo has been released the backward or inboard movement of the torpedo-casing is effected by fluid under pressure in a positive manner by means of a mechanism to which fluid under pressure is admitted automatically when the torpedo-casing has reached the torpedo-releasing position. Five claims.

802,648. MEANS FOR PROPELLING SHIPS. JOHANN C. KUNST, BRAKE, GERMANY.

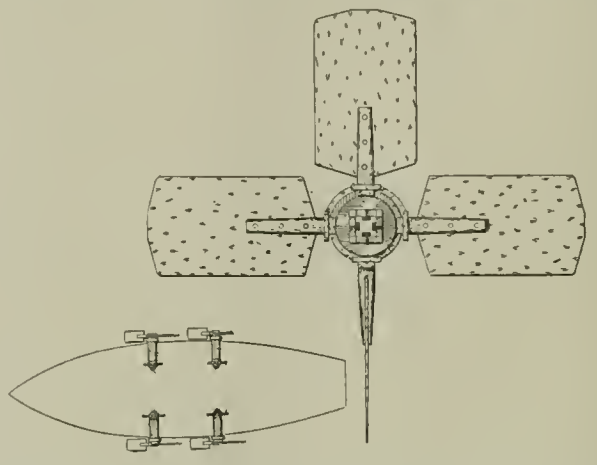
Abstract.—The invention relates to improvements in means for propelling ships; and it substantially consists in arranging within a paddle-wheel a



motor adapted to drive the said wheel. This motor can be a steam-turbine, an electromotor, or any other motor suitable for the purpose. Seven claims.

802,602. PROPELLER FOR BOATS. HERMAN S. SEARLE, ROCHESTER, N. Y.

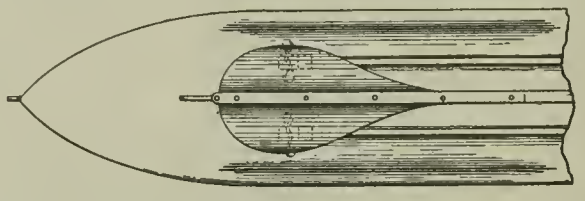
Abstract.—The main object of the invention is to construct the paddles so as to turn in their respective bearings in the shaft and to provide simple



means for turning them automatically at intervals on their axes as they are collectively carried around by the revolving shaft to cause the blades of the paddles to alternately present their faces and their edges to the water. Three claims.

804,497. HULL OF VESSELS. ISAAC E. PALMER, MIDDLETOWN, CONN.

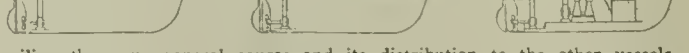
Claim.—2. The combination with the hull of a vessel provided with a channel at the stern portion thereof, of laterally-extended wings forming



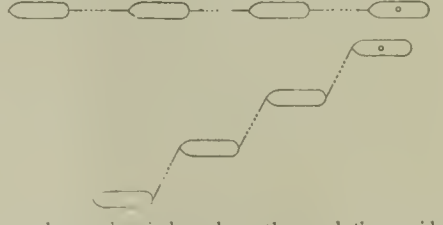
a bottom to said channel and spaced from the wall of the channel to leave an opening for the escape of the water laterally from within the channel, the said wings being constructed to vanish into the keel of the vessel as they extend forward, whereby a free flow of water is maintained through the channel. Four claims.

805,268. MARINE TRANSPORTATION UNIT. WILLIAM T. DONNELLY, BROOKLYN, N. Y.

Abstract. The invention provides for the generation of propelling power, such as electricity, upon one of a fleet or convoy of vessels that are

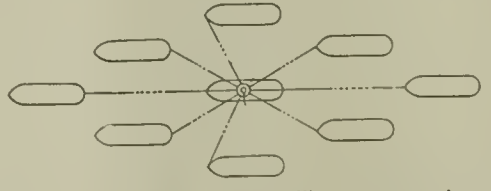


sailing the same general course and its distribution to the other vessels in such a manner that they will be free to make use of it for propulsion and at the same time be free to navigate independently in the vicinity of



the fleet as regards speed, wind, and weather and the avoidance of local obstructions.

Claim.—4. A marine transportation unit comprising a plurality of vessels, one of said vessels having propelling means, steering means and an electric



generating plant for operating the propelling means, and each of the other vessels having independent steering means and independent propelling means operated by electric power supplied from the generating plant of the first-mentioned vessel, substantially as described. Nine claims.

For the photograph and description of the steamer *E. C. Waters*, which appeared at page 520 of our December number, we were indebted to Mr. Elisha Webb, Jr., of Philadelphia.

Marine Engineering

FEBRUARY, 1906.

LONGITUDINAL BENDING MOMENTS OF CERTAIN LAKE STEAMERS.*

BY W. I. BABCOCK.

In 1895 I designed and built at Chicago the steamer *Victory* for the bulk-freight trade on the great lakes. She was then the largest vessel that had ever been built in fresh water and the first one to reach 400 feet in over-all length, her keel being 380 feet, beam 48 feet, and depth 28 feet, with a displacement of about 8,400 tons (net) on 18 feet draft of water. On this draft she carried 5,200 gross tons of iron ore.

The *Victory* was also one of the earliest lake ships to be built on the channel system, the floors, frames, web frames, beams, ties, and stanchions all being of channel section. The upper deck was of steel complete, without wood covering. The main-deck beams were spaced uniformly 8 feet apart, making a beam at each end of a hatch and one beam in the center between hatches, the hatches through the upper deck being 8 feet fore-and-aft and 24-feet centers. No deck was laid on the main-deck beams throughout the cargo hold, but a web frame or belt was fitted at each beam end and a stanchion on the center line, with two rows of ties on each side and steel-plate shifting boards below the upper deck on the stanchions. Large brackets were fitted at beam ends and center line.

Throughout the ship, extending from forward collision to after-peak bulkheads, was fitted a double bottom 4½ feet deep, of 10-pound plate, stiffened by Z-bars, and covered with 3 inches of oak flooring, supported by continuous longitudinals on top of floors. This bottom was divided by center keelson and high-plate floors into eight watertight compartments.

The machinery was placed as far aft as possible, consisting of a triple-expansion engine 23, 38, and 63 inches by 40 inches, and two Scotch boilers 14 feet 8 inches by 13 feet placed on a half-deck about 9 feet above the inner bottom, facing each other, with fire room between and coal bunker next forward. Accommodations for the crew and three or four passengers are all in forward and after ends of the ship, leaving the deck unobstructed as far as possible for convenience in handling cargo, which is all handled from the docks, there being no hoisting appliances whatever on the vessel.

THE STEAMER ELBERT H. GARY, OF THE UNITED STATES STEEL CORPORATION FLEET.

Thus built, the *Victory* ran for ten seasons, a successful and fortunate ship and a profitable one for her owners, mostly in the business of bringing iron ore from Lake Superior to Lake Erie ports and going back light, but occasionally, when freights were attractive, taking coal up or a load of grain down. In that time, however, and particularly in the last two or three years, there has been a great change in the conditions of lake business. This has been caused mainly by the great development that has taken place in the dock appliances for the unloading of bulk cargoes of iron ore. When the *Victory* was built, and for years afterward,

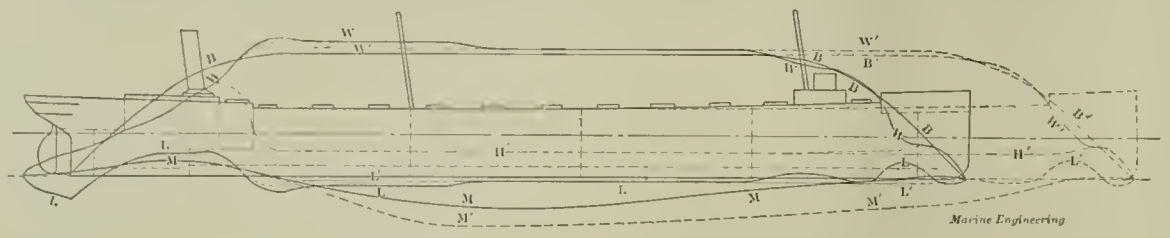
*Read at the thirteenth general meeting of the Society of Naval Architects and Marine Engineers, November 17, 1905.

the unloading buckets used were ordinary tubs, holding about one ton, with four small wheels on the bottom, so that they could be moved about in the hold, and the ore was shoveled into them by hand. It was then an advantage to have the ore pile in the ship as shallow as possible, so that the shovelers could get quickly to the bottom. Now, great hydraulically- or electrically-operated self-filling buckets or grabs, of five- to ten-tons' capacity, dig their own way into the cargo, and nearly all of it is unloaded without any hand work at all, the shovelers being required only at the last in cleaning up the scattered remnants. In operating this modern power bucket in the hold it is evident that the fewer obstructions there are the better, and that the hatches should be as large and as close together as possible. Also, that the ore pile should be concentrated on a small bottom area and, therefore, be deep or high. From these considerations there has been evolved the modern vessel, in which the hatches are 9 feet wide, spaced 12 feet centers, the main-deck beams and the stanchions omitted entirely, and the tank top bent up to meet the main-deck stringer in various forms, but all with the idea of forming a long hopper or trough in which the ore lies and which presents a smooth surface everywhere to the buckets. The amount of water ballast that can be carried is largely increased at the same time, which is a great advantage, as the boats usually go light to the upper lakes. The strength is made up by carrying a heavy plate girder or arch across under the upper deck between each two hatches, connected to heavy plate webs running right around the ship.

With the increase in the amount of cargo that can be unloaded in a day by this improved machinery and construction, and the steady increase in the draft of water available in the Soo and Detroit rivers and the lake harbors, due to government and private dredging, the size of the vessels has grown steadily also until now there are many on the lakes with a capacity of over 10,000 gross tons per trip each.

four hatches, fitted with telescopic covers made of steel plate and opened and closed by three special engines on deck through shafting, clutches, and chains.

The running expenses of these very large ships are very little more than those of the old boats, practically the same crew being carried, and it is evident, therefore, that the cost of carrying a ton of cargo is very much less. To bring down this cost in the old boats a number of them have been lengthened, increasing the capacity considerably with no increase in the running expenses and very little loss of speed. This was done last winter in the case of the *Victory*, 72 feet being added amidships, making her now 452 feet keel and giving an increase in cargo of some 1,400 tons on 18 feet draft. At the same time a new steel tank top was put in without wood covering and the main-deck beams were moved away from the line of the hatches, so as to leave as much clear space as possible for the operation of the unloading machinery.

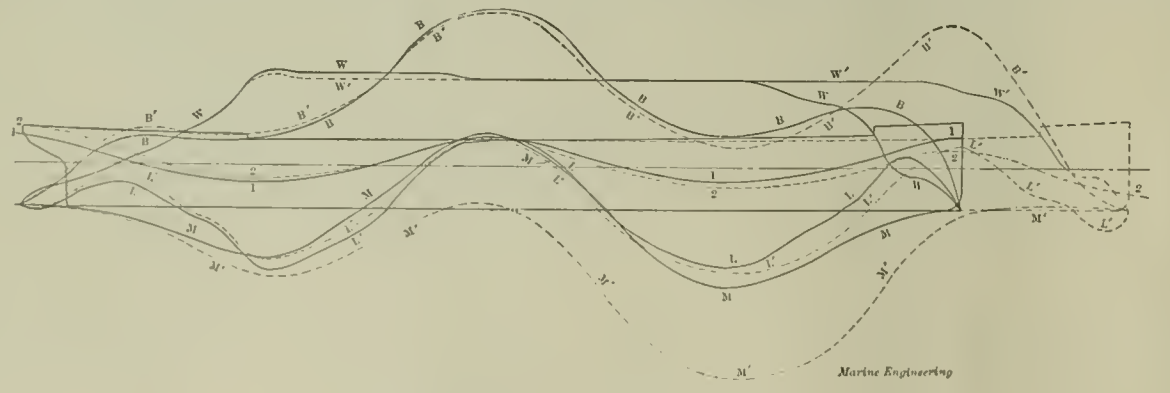


CURVES FOR THE VICTORY IN STILL WATER.

It occurred to me that it would be interesting to investigate the changes in the longitudinal bending moments in a seaway in this ship caused by this increase in length, and to compare these also with the bending moments of the largest ships now in lake service for the same series of waves, and I now have the pleasure of presenting the results of this investigation to the society.

The waves met with on the great lakes of America are uniformly short, though they may be relatively high. From all the information I have been able to get, I fixed upon a wave 200 feet long and 20 feet high as the maximum size likely to be encountered, and made the calculations on that wave as a basis. I doubt very much whether this length is ever reached, though possibly the height may be slightly exceeded on rare occasions.

In starting the investigation the only data I had for the *Victory* were for a draft of 18 feet, and I therefore have used that draft for that boat and the same for the *Gary*. As my object was only to determine the relative strains due to increase of length, and not the actual stress in the material, the actual draft for which the calculations are made does not make any particular difference. During the past season the boats have been loading to between 19 and 20 feet.



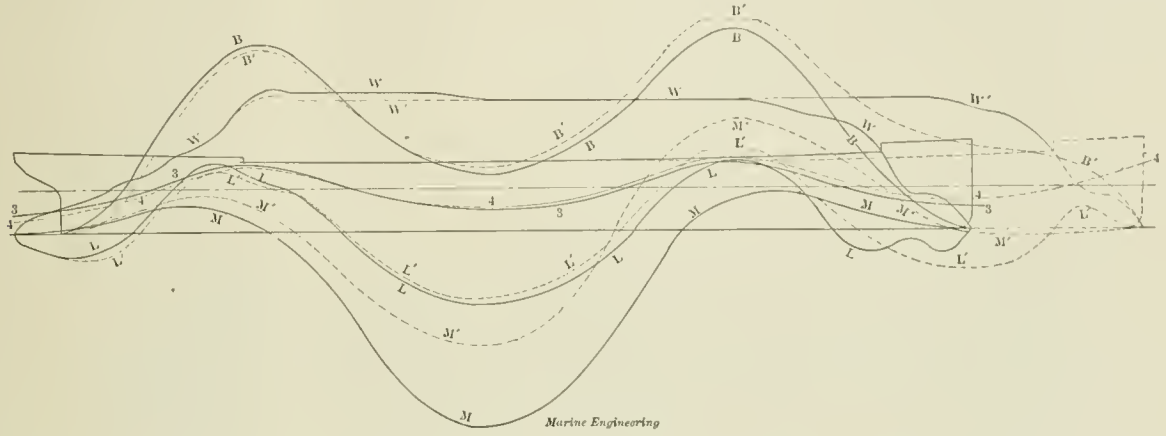
VICTORY ON WAVES WITH CREST AT ORIGINAL BOW.

As an example of the latest boats, the steamer *Elbert H. Gary*, of the fleet of the United States Steel Corporation, may be taken. This ship is 500 feet over all, 549 feet keel, 56 feet beam, and 31 feet deep. She has a triple-expansion engine 24, 39, and 65 inches by 42 inches, and two Scotch boilers 15 feet 4½ inches diameter by 11 feet 6 inches long, and with 10,500 tons cargo on a draft of 19½ feet makes 12 miles per hour with about 2,000 horsepower. The cargo has been loaded in four hours and thirty minutes and taken out in four hours and ten minutes. This boat has thirty-

For each case the distribution of the cargo fore and aft in making up the curve of weights has been taken from actual records kept on the ship.

For the *Victory*, each figure gives an outline of the ship, dotted

for the increased length, the curves of weight, *W* and *W'*, the water or wave lines, the curves of buoyancy, *B* and *B'*, the curves of loads, *L* and *L'*, and the curves of bending moments, *M* and *M'*, for the original and the new lengths respectively, the position of the crest of the wave with reference to the stern being the same. For the *Gary* there is, of course, only one set of curves for each wave position.



VICTORY ON WAVES WITH HOLLOW AT ORIGINAL BOW.

These curves are given for the ship in still water, and in it I have added the weight curves for the vessel alone with 100 tons fuel, but without cargo. It shows, what is practically universal in lake ships, a sagging moment for the greater part of the length, when the vessel is loaded, which at its maximum, however, is only 7,000 foot tons for the original and 11,000 for the new length, being respectively 1-456 and 1-424 the product of the length and displacement.

The curves are also given for the ship in a series of waves with the crest of the first wave coming at the bow of the old length The maximum hogging moment is 15,800 foot tons for the old and 1,000 foot tons for the new length, or 1-200 and 1-4,670 the product of the length and displacement respectively. The maximum sagging moments are 17,200 foot tons for the old and 37,100 foot tons for the new lengths respectively, or in fractions as before 1-186 and 1-125.

The ship is shown on a series of waves with the hollow of the first wave at the bow of the old length. The maximum hogging moment is 8,100 foot tons for the old and 23,200 foot tons for the new length, or 1-400 and 1-200 the product of the length and displacement respectively. The maximum sagging moments are 41,400 foot tons for the old and 24,500 foot tons for the new lengths respectively, or in fractions as before 1-77 and 1-190.

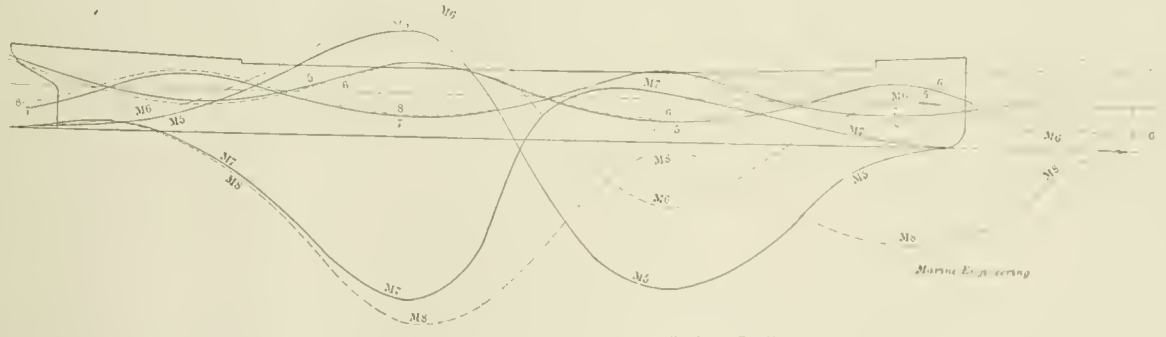
The bending moment curves only are shown in another plate, the others being omitted to avoid complication, for wave positions in which the crest and the hollow of the first wave come at the bow of the new length respectively. For the original ship the maximum hogging moment is 21,800 foot tons (1-152) and the maximum sagging moment is 34,700 foot tons (1-92). For the lengthened ship the maximum hogging moment is 26,700 foot tons (1-175) and the maximum sagging moment is 40,000 foot tons (1-117).

It is doubtless unnecessary to discuss these various figures in further detail. The drawings are plain and there are a sufficient number of different positions of waves illustrated to give the maximum bending moments which are ever likely to occur. From them we observe that the maximum hogging moment is about 21,800 foot tons for the original ship and 26,700 foot tons for the lengthened ship, an increase of about 22½ percent. The maximum sagging moment is 41,400 foot tons for the original and 40,000 foot tons for the lengthened ship. In any position which this vessel is ever likely to assume among waves it is fair to believe that the sagging moment will always be considerably in excess of the hogging moment.

For purpose of comparison with the curves of the *Victory*, similar calculations have been made on the steamer *Elbert H. Gary*, which is one of four sister ships which are now the largest in service on the lakes. Curves are given for this ship, lettered the same as in the case of the *Victory*. They explain themselves. The maximum sagging moment for the loaded ship in still water is 40,700 foot tons or 1-200 the product of the length and displacement. For the various waves shown the maximum hogging moment is 40,200 foot tons (1-200) and the maximum sagging moment is 97,500 foot tons (1-84).

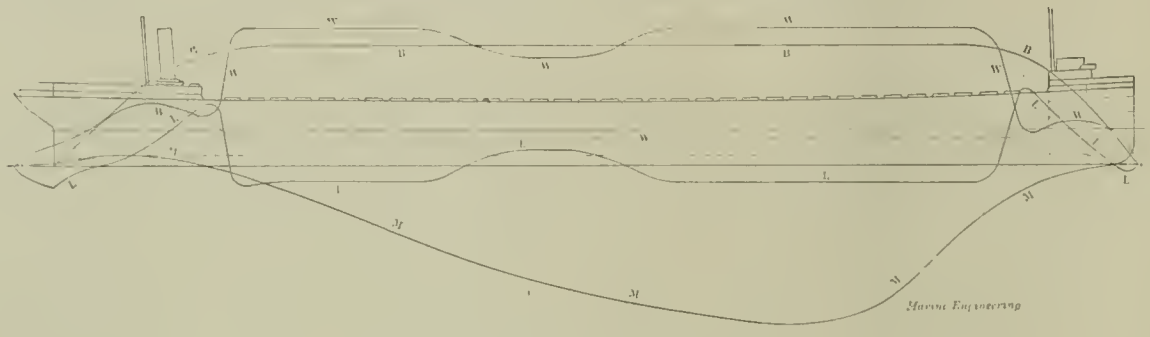
Comparison between the still-water conditions shows at once an important difference in the two ships. In the case of the *Victory* the forward hatch is considerably nearer the bow than in the *Gary*, and there being a cargo space underneath the boilers and coal bunkers, the ore from the after hatch trims aft underneath the boiler deck. This results in a more even distribution of the curve of weights for the loaded condition of the ship.

In the case of the *Gary* the boiler room and coal bunker extend down to the tank top and the ore at the after end can go very little aft of the line of the after hatch. At the forward end of the *Gary* the forward hatch is kept back from the forecastle



BENDING MOMENT CURVES FOR THE VICTORY.

house to give room for the winches which handle the wire hawsers. The result is that in this ship there is a considerable excess buoyancy both forward and aft of the cargo, whose result is seen in the curves which show a large increase in the sagging moment. This effect is aggravated by the practice on the *Gary* of not loading any ore at all into the forward hatch, which is done to facilitate the discharge of cargo, the unloading buckets, working through the forward hatch, being able to reach all of the ore, which would hardly be the case if any were loaded into that hatch. It is usual on the *Gary*, in order to reduce the sagging moment, to lighten up the amount of cargo loaded into the midship hatches. This is good practice, but leaving the cargo out of the forward hatch is not to be commended, though it is frequently done in lake ships.

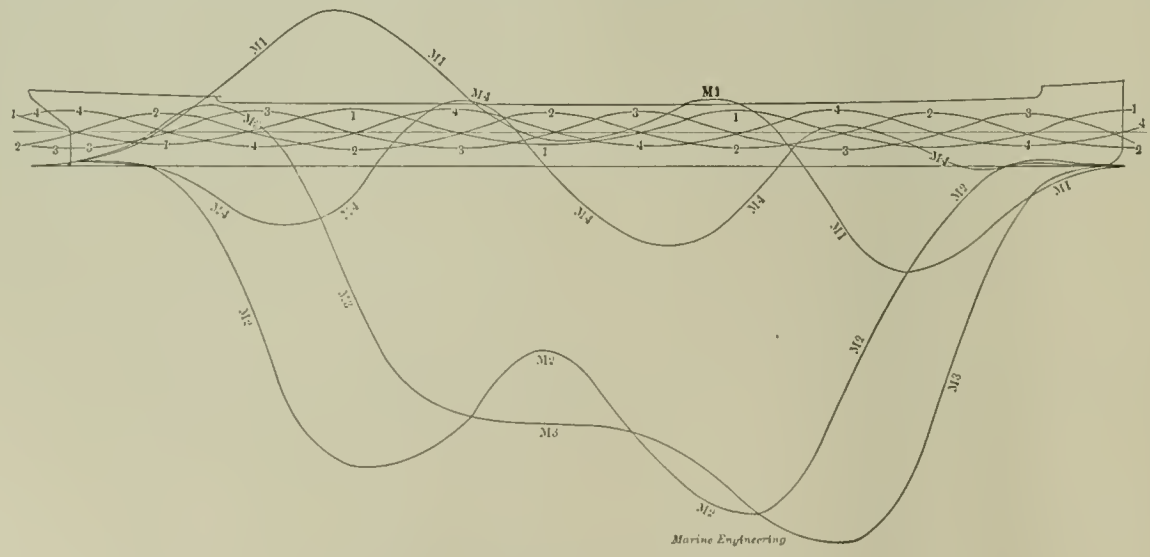


CURVES FOR THE ELBERT H. GARY IN STILL WATER.

In one case a crest of wave No. 2 comes nearly opposite the boilers, where there is already an excess of buoyancy in still water, as shown, and the result is seen in the increase of the sagging moment a short distance forward.

Similarly wave No. 3, drawn so that its crest comes just forward of the forward hatch where there is again a large excess of buoyancy in still water, causes another very large increase in the sagging moment a few hatches further aft.

A comparison of the various curves shown in the figures indicates that in any condition of the loaded vessel, in still water or among waves, the sagging moment is in excess, and generally very much in excess, of the hogging moment. Considerable criticism, therefore, which has at various times been indulged in as to the heavy bottoms of lake ships in comparison with their upper works, is shown to be largely unwarranted. This construction of the vessel has been a natural outgrowth of the conditions of the business, which require a very heavy bottom to resist the strains due to frequent grounding and touching in narrow and shallow channels, and also to support the weight of the cargo on the tank top, and also require the upper-deck hatches to be as numerous



THE GARY IN WAVES WITH CRESTS AND HOLLOWS RESPECTIVELY AT BOW

The conditions under which the iron-ore business of the lakes is carried on make it impossible to avoid these large excesses of buoyancy forward and aft of the cargo. In a service where the boats can run but seven months in the year despatch in handling cargoes is of the utmost importance. At upper-lake ports the ore is simply spouted in from elevated docks. Practically, therefore, everything about the boats is subordinated to the requirements of the unloading machinery at the receiving docks on the lower lakes. If a ship could be built so that she came to these docks with all her ore in one deep pile amidships and the whole upper deck could be taken off to leave this pile open to the dock machinery, possibly then the dock managers would be satisfied. Failing this ideal condition the shipbuilder has to come as near to it as possible and take care of the other qualities of his ship as best he can. I will venture to say, however, that nowhere else in the world is there a fleet of ships better fitted to the conditions under which they must work than on the great lakes, where boldness and originality of design have had freer scope or been more successful, or where, on the whole, fewer mistakes and failures have been made.

and as wide as possible to facilitate unloading. These combine to make the bottom heavy and the deck light, and therefore considerably lower the position of the neutral axis. It is satisfactory to know that the strains which come upon the ship in deep water among waves are very well met by the same construction, for the compression on the upper deck is always much more severe than the tension and to resist this compression it is comparatively easy to stiffen the stringer by one or more lines of intercostals between the beams, as shown in the midship sections illustrated herewith.

If the *Gary* were in service in salt water instead of on the lakes,

and therefore liable to encounter ocean waves which are, of course, much longer from crest to crest, the bending moments would naturally be greatly increased. For comparison I have calculated these moments for a wave of the same height as used before, 20 feet, and a length equal to the over-all length of the ship, 570 feet, with the crest and hollow at mid-length respectively, and the results are shown.

For the crest at mid-length the hogging moment is 165,300 foot tons or 1-33 the product of the length and displacement. For the hollow at mid-length the sagging moment is 257,900 foot tons or in fractions as before 1-21. The hogging moment is about the same as given by White as the maximum for ordinary merchant steamers. The sagging moment is between two and three times as great as given by the same authority. This is the natural effect of the full model of lake vessels—the box coefficient of the *Gary* at 18 feet being .86—and the excesses of buoyancy forward and aft as referred to before.

The greatest tensile strain on the deck of the *Gary*, therefore, is only one-fourth of what it would be if the ship were on salt water and in a series of waves of her own length. The maximum compression on the deck is a little less than two-fifths of what it would be under similar circumstances. If it were not for these facts the very wide hatches of lake steamers would be impossible and the handling of bulk cargoes would be greatly interfered with.

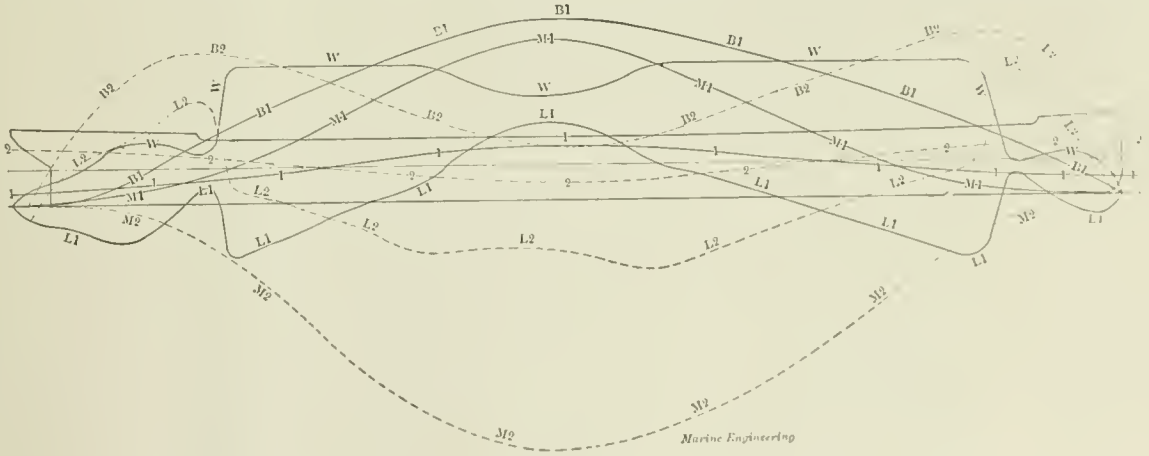
No attempt has been made to investigate the strains on either of these vessels when going up without cargo. From the nature of the case it is practically impossible to do so. In smooth water water ballast is carried aft only and added forward as the sea rises. There is no question but that in the past various vessels have been greatly abused, water ballast being carried aft only to get the wheel down and the vessel forced against head seas, jumping many feet of her bow clear of the water with a resultant heavy tensile strain on the deck. It is doubtless true also that many vessels are severely strained in unloading, too much ore being taken out at one place before the machines are moved. Definite calculations, however, cannot be made on such conditions.

Since the new power unloaders have brought the hopper type of vessel into existence the amount of water ballast that can be carried has been largely increased until on a vessel like the *Gary* it amounts to about 8,000 tons and puts her down to a draft which makes the ship perfectly safe under all conditions.

THE GARY, WHICH RECENTLY CARRIED A CARGO OF 12,320 TONS OF IRON ORE.

The United States Steel Corporation has just placed an order for two ships 600 feet in over-all length, 58 feet beam, and 32 feet deep, to come out next year. To reduce as much as possible the excess buoyancy forward in these vessels, the forward hatch has been moved close to the forecastle and the third hatch omitted, the winches being placed on the deck in the space which that hatch would otherwise occupy, thereby carrying the ore body further toward the bow.

Editor's Note: The midship section of the steamship *Victory* has been taken as a basis for calculating the stress experienced in various parts of the structure of the ship due to her being placed upon the waves in question. It must be understood that such a calculation as this can give only approximate results, because no allowance can be made for either the corkscrew twisting motion to which ships are subjected when crossing waves diagonally, or the dynamic effects due to the buffeting of waves, from whatever quarter they may approach.

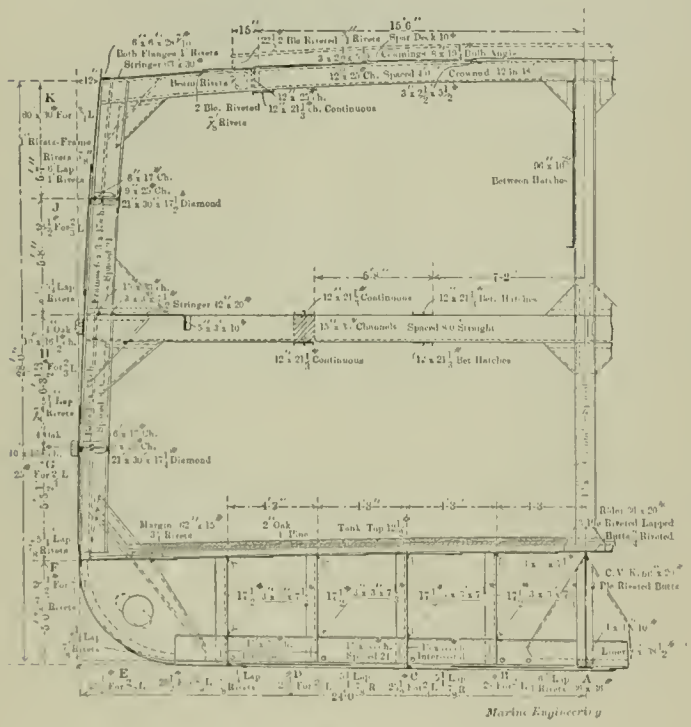


THE GARY IN ATLANTIC WAVES, OF SAME LENGTH AS SHIP.

The data given on the midship section as illustrated in Mr. Babcock's paper was used for this computation, and trial neutral axes were taken at 10 feet 5½ inches above the base line for

sagging and 8 feet 3 inches above the base line for hogging. The riveting, wherever it was not given in detail, was figured from the rules of the Great Lakes Register, and proper allowance made for rivet holes in all members subject to tension, these members being, of course, those above the neutral axis when the ship is undergoing hogging stress, and those below the neutral axis when the stress is of the sagging character.

As computed, the cross sectional area of all continuous longitudinal members is 1,532 square inches. The total rivet area is 329 square inches, and the net area after removing all rivet holes is 1,203 square inches. For sagging, the area figures out at 1,315 square inches; while the difference between the moments above and below the neutral axis shows the latter was assumed about 1¼ inches too high. Correcting for this difference, the total moment of inertia of the section under sagging conditions becomes 133,974, in the conventional units made up of square inches times square feet. For hogging, the net area of the section is 1,468 square inches, and the correction of neutral axis due to incorrect assumption is less than ¼ inch. The resultant moment of inertia of the entire section for hogging becomes 122,434 units, as above described.



MIDSHIP SECTION OF VICTORY.

A number of results are given quantitatively in Mr. Babcock's paper, being the maximum bending moment under each of several conditions. These quantitative results, however, do not cover completely all the cases which he investigated, and the others included in the table herewith have been deduced from his curves as reproduced. From the same curves have been obtained the positions with regard to the midship section of the ship of the points at which the maximum bending moment occurs in each instance. It will be noticed that these distances vary markedly, in some cases being in the neighborhood of 100 feet forward or aft of the midship section. With the long dead-flat sections of lake steamers, it is a fair assumption that the midship moment of inertia will be maintained for a long distance forward or aft of amidships; and even after the area of section begins to undergo change the moment of inertia of the new form of section will not vary much from that amidships. On this assumption, the stresses have been calculated for both keel and upper deck stringer, for sagging and hogging conditions of the ship, and with five different wave conditions for both the original ship and the ship finally lengthened. These conditions are respectively: still water; wave crest at bow of original ship; at bow of new ship; wave hollow at bow of original ship; and at bow of new ship. The distances from the corrected positions of the neutral axes to the keel are; for sagging, 10.47 feet; for hogging, 8.39 feet. For the upper deck stringer these distances are respectively 15.76 and 17.89 feet.

By use of the usual formula, $p = \frac{Me}{I}$, where p is the stress in tons per square inch, M is the bending moment in foot tons, e is the distance in feet from the neutral axis to the fiber under investigation, and I is the moment of inertia of the section in units as given above, the stresses above mentioned have been calculated, and are shown in the table. It will be noticed that the highest stress given for the original ship is 4.87 tons per square inch, which occurs in the deck stringer under sagging conditions with the wave hollow at the original bow. The highest value for the lengthened ship is 4.7 tons per square inch, which occurs under sagging conditions with the crest of the wave at the new bow. Both these values are very moderate as compared with those experienced in similar structures on the sea board, and of course all the other values, being considerably smaller in quantity than these, are such as need cause no uneasiness whatever regarding the strength of the ship.

RESULTS FOR ORIGINAL SHIP.

CALCULATED STRESS.

	Sagging Moment		Hogging Moment.		Sagging.		Hogging.	
Position of wave.	Maximum	Position.	Maximum	Position.	Keel.	Stringer.	Keel.	Stringer.
No wave.....	7,000	15 ft. aft	none	.....	0.54	0.83	.....	....
Crest at original bow..	17,200	90 ft. ford	15,800	10 ft. aft	1.35	2.02	1 08	2.31
Hollow " " " ..	41,400	15 ft. aft	8,100	110 ft. ford	3.24	4.87	0.55	1.18
" " " new " ..	30,100	70 ft. ford	21,800	45 ft. aft	2.36	3.55	1.40	3.17
Crest " " " ..	34,700	40 ft. aft	11 300	50 ft ford	2.71	4.09	0.77	1.65

RESULTS FOR LENGTHENED SHIP.

No wave.....	11,000	55 ft aft	none	.....	0.86	1.20	.....	..
Crest at original bow..	37,100	55 ft. ford	1,000	45 ft. aft	2 9	4.36	0.07	0.15
Hollow " " " ..	24.5 00	50 ft. aft	23,200	45 ft. ford	1.02	2.88	1.59	3.38
" " new " ..	13,700	35 ft. ford	26,700	80 ft. aft	1.07	1.61	1.83	3 88
Crest " " " ..	40,000	70 ft. aft	1.000	near stern	3	4.7	.....	.....

THE NEW P. & O. LINER DONGOLA.

BY BENJAMIN TAYLOR.

A new addition to the world-famous fleet of the Peninsular and Oriental Steam Navigation Company is always an event of the first importance and interest in the shipping world, because these steamers, carrying the whole of the mails and the best of the passenger and cargo traffic between Great Britain and the Far East, always embody the latest developments in marine architecture and equipment, and the most modern and approved achievements in marine engineering. The *Dongola*, which is the latest addition to this extensive fleet, was launched on the 14th of September, 1905, from the yard of Barclay, Curle & Company, Limited, Clydeholm, near Glasgow. This vessel is of a class specially designed for the Eastern mail service of the P. & O. Company, and has a combination of speed and spacious passenger accommodation, with large measurement and dead-weight carrying capacity. She presents in one structure qualities formerly obtainable only in two or more different types.

The leading dimensions of the *Dongola* are:

Length, overall	490 feet.
Breadth, extreme	56 feet, 5 inches
Depth from bottom of keel to top of deck at center	36 feet, 8 inches
Gross registered tonnage, about.....	8,100 tons.

DECK VIEW OF DONCOLA DURING CONSTRUCTION.

transport service have also been complied with, so that the vessel is available for the transport of troops in time of war.

The hull is of the best Siemens-Martin open hearth mild steel, the scantlings being in excess of the requirements of Lloyd's, with the object of providing increased strength and also of providing a margin against the deterioration common to steel vessels. The hull is divided into separate watertight compartments to insure the flotation of the vessel should the skin be accidentally pierced; and to provide for safety in the event of grounding or touching a sunken rock, a complete inner bottom has been fitted fore and aft, divided by numerous watertight partitions into separate water-ballast tanks, each tank being capable of being filled or emptied independently.

There are three decks laid fore and aft; a lower deck of pitch pine, a main deck of steel sheathed with pitch pine, and an upper deck of steel sheathed with teak. Above the upper deck is, at the fore end, a forecastle 103 feet long, and, at the after end, a long combined poop and bridge deck 320 feet long. Both of these decks are of steel, sheathed with teak. The combined poop and bridge forms the lower promenade deck, and above this is the upper promenade deck of teak, 190 feet long, assigned to

BOW VIEW OF NEW SHIP JUST BEFORE LAUNCHING.

The machinery consists of quadruple expansion twin-screw engines of 8,000 indicated horsepower, constructed by the builders, developing a speed at sea of 15½ knots. She will carry 150 first-class and 100 second-class passengers. The requirements of the first-class passengers. Above this are the boat deck, lower navigating deck, and upper navigating deck, all of teak. The total depth of the ship to the upper navigating deck is 80 feet, or 56 feet above the level of the water.

The arrangements for passenger accommodation are designed to give the maximum space and comfort to each individual. The first-class passengers' cabins are all amidships, partly on the upper deck and partly on the promenade deck. Only one row of cabins is fitted on each side amidships, instead of the usual practice of two rows each side. The passages are unusually wide, well lighted, and well ventilated. The dining saloon is situated at the fore end of the upper deck, and extends the full breadth of the ship. There are large circular lights on three sides of the saloon, and an open well overhead, which extends through four decks to a large skylight on the upper navigating deck. The decoration of the saloon is in good taste, the walls being paneled in inlaid mahogany, with specially designed Tynecastle canvas for the frieze and ceiling. The furniture consists of chairs, tables, settees, and sideboards of inlaid mahogany with beveled glass mirrors. Electric bells, fans, and lights are provided here as elsewhere throughout the vessel. Leading from the dining saloon to the music room on the upper promenade deck is a handsome stairway in two flights, with a large open space on the lower promenade deck, giving access to the deck cabins. The music room is large and decorated in inlaid mahogany, with Tynecastle canvas panels on the ceiling and frieze on the walls. It is well lighted by numerous lights on four sides and by two large skylights overhead. This room is furnished with piano, couches, tables, etc. Direct access is obtained from it to the upper promenade deck, and from the halfway landing to the lower promenade deck. At the after end of the upper promenade is the smoking room, which is lofty, the ceiling being two feet higher than any other room in the ship. The paneling is of light oak, and a deep frieze and ceiling of Tynecastle canvas fitted. Numerous couches, chairs and tables divide up the space into small compartments. Access to the smoke room is obtained through a vestibule lined in fumed oak, from which a stairway leads down to the after vestibule.

The sanitary accommodation is in numerous small blocks, each complete in itself, at different points throughout the passenger accommodation. Porcelain baths with hot and cold water, hot and cold showers, marble topped wash basins with hot and cold water, and all other necessaries, are provided in large numbers, and passengers can go from their rooms to any of the public rooms without going on deck.

The second-class passengers are accommodated in the after end of the vessel, and the dining room, smoke room, entrance hall, and sanitary accommodation are all arranged with the same care and attention as the first-class.

THE DONGOLA, READY FOR SEA.

For the stewards' department large store rooms are provided on the lower deck, and a refrigerating chamber, with separate compartments for preserving meat, game, fish, and vegetables, also an ice-making room. The temperature of these chambers is kept at any desired point down to freezing point by means of a refrigerating machine on the dry-air system in the engine room. The galley is on the upper deck, and is fitted up with cooking ranges, baking ovens, hot water boilers, grills, *bain-maries,* etc. Large pantries are fitted adjoining each dining saloon, with hot and cold water, and carving tables heated with steam.

The electric light installation consists of three independent dynamos, each driven by a compound engine, and a complete system of electric lighting and fans throughout the vessel, including navigating lights and large clusters for use when discharging cargo at night. The ventilation of the vessel is designed for the hot climate in which she will run, and includes a special system of ventilation to the troop deck.

SIDE VIEW OF THE SHIP IN HER BUILDING BERTH.

The accommodation for the captain and officers is entirely on the navigating deck; a large chart room and wheel house contains the steering wheel and other navigating appliances, Kelvin compasses, engine room telegraphs, docking and steering telegraphs, speaking tubes to the engine room and captain's room, and loud-speaking telephones to the engine room, forecastle head, and the after end of the vessel complete the appliances for working the ship. The engineers are berthed on the upper

deck, alongside the entrance to the engine room, with their mess room and lavatories alongside. The seamen, firemen and stewards are all berthed forward, partly under the forecastle deck and partly under the upper deck.

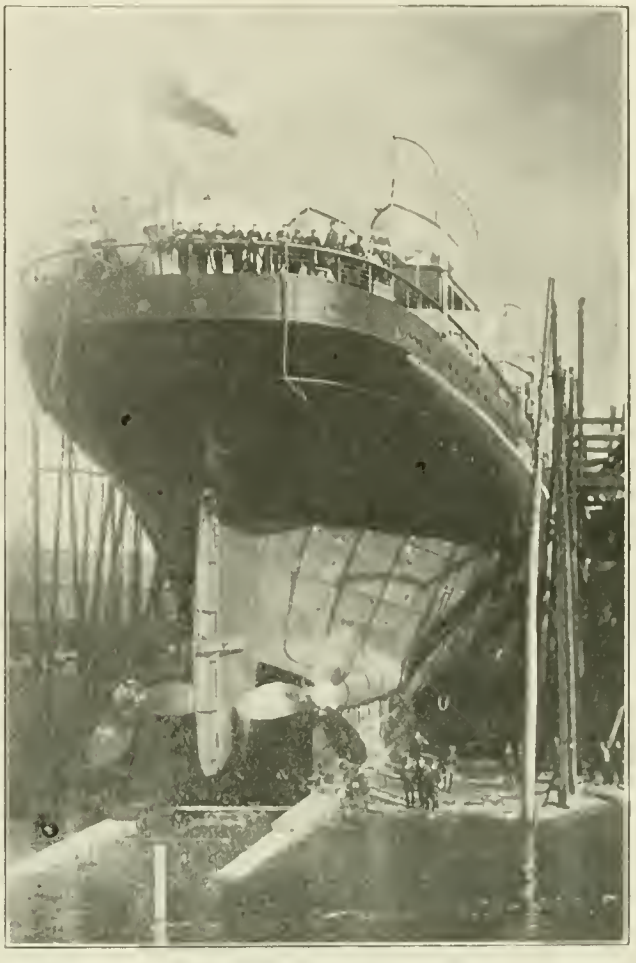
As the vessel is designed to serve as a troopship when required, the troop deck extends full length below the upper deck, two watertight doors being fitted in each watertight bulkhead to allow an uninterrupted passage from end to end, and numerous large side lights are fitted fore and aft. Ample latrine accommodation is placed at the fore end, under the forecastle.

The steam steering gear is fitted in a steel house immediately over the rudderhead, and is actuated by telemotor gear from the bridge and aft; and hand steering gear is fitted for use in the event of a breakdown of the steam gear. The appliances for mooring the ship consist of cast-steel stockless anchors, stowed in the hawse pipes, with heavy cables of the best quality; a large steam windlass on the forecastle head, with a steam capstan forward; and two steam warping capstans placed on the poop deck aft.

The cargo loading and discharging facilities are five large cargo hatchways served by six powerful steam cranes, four steam winches, powerful derricks, and a special derrick capable of lifting 30 tons.

The ship carries 14 lifeboats, fitted with Andrews' patent lowering and disengaging gear, and those amidships are fitted on the rail of the promenade deck on Andrews' principle, so as to leave as much deck space as possible for the passengers. The boats include a large steam launch, capable of steaming 10 knots. Mail rooms and bullion room are fitted up on the lower deck aft, built of steel and fitted with Chubb's doors. The space between the twin screw tunnels is utilized for fresh water tanks, the total capacity being about 40,000 gallons.

The machinery, constructed by the builders, consists of two sets of quadruple expansion engines, the diameter of the cylinders being 25½, 36½, 52 and 74 inches, with a stroke of 51 inches. The cylinders are arranged to give the best balance possible for smooth and silent working. The second intermediate cylinder and the low-pressure cylinder are both steam jacketed; flat slide valves are fitted to the second intermediate and low-pressure cylinders, and piston valves to the others. Direct steam starting and reversing gear is fitted, also steam and hand gear for turning the engines in port. The surface condenser is horizontal, of cast iron, the condensing surface being 12,000 square feet.



STERN VIEW BEFORE LAUNCHING.

The shafting throughout is forged from the best ingot mild steel, about 10 percent in excess of Lloyd's requirements. The

THE BATTERIES OF BOILERS SET UP IN THE SHOP.

propellers are three-bladed, with cast iron bosses and blades of manganese bronze.

The boilers are six in number, two double-ended 20 feet long, and four single-ended 11 feet 6 inches long; all 14 feet 8 inches diameter, with a working pressure of 215 pounds per square inch. Each boiler is fitted with three furnaces in each end, 3 feet 5½ inches in diameter. Forced draught on Howden's system is fitted, with two fans electrically driven. The total number of furnaces is 24, the heating surface 18,700 square feet, and the grate surface 470 square feet; ratio, 39.8 to 1. The machinery is estimated to develop 8,000 indicated horsepower on trial, and a speed of 16 knots.

The outfit of auxiliary machinery in the engine room consists of fourteen steam pumps, including circulating and air pumps, feed, bilge, ballast, wash deck, fire, hot and cold fresh water and sanitary pumps. Steam ash ejectors, feed water evaporator, fresh water distilling, and evaporating and filtering plant are fitted in the engine room, also the refrigerating machinery and a triplicate set of electric generating plant.

The keel of the *Dongola* was laid on the 10th of January, 1905, and she was ready for launching by the 14th of July, but owing to a strike of patternmakers the machinery was not then ready. Even with this delay, the vessel was handed over to the owners ready for service within nine and a half months from the laying of the keel. But for the strike referred to, she would have been ready in eight months from beginning work.

Progress of Naval Vessels.

The Bureau of Construction and Repair, Navy Department, report under date of January 10, 1906, the following percentage of completion of vessels building for the United States Navy:

			Dec. 1.	Jan. 1.
BATTLESHIPS.				
Virginia	19 knots.	Newport News Co.	97.	98.
Nebraska	19 "	Moran Brothers Co.	83.	84.24
Georgia	19 "	Bath Iron Works.	90.15	91.24
New Jersey	19 "	Fore River Shipbuilding Co.	93.7	95.5
Rhode Island	19 "	Fore River Shipbuilding Co.	98.	99.
Connecticut	18 "	Navy Yard, New York, N. Y.	92.66	93.69
Louisiana	18 "	Newport News Co.	92.56	94.17
Vermont	18 "	Fore River Shipbuilding Co.	68.7	70.7
Kansas	18 "	New York Shipbuilding Co.	67 7	69 8
Minnesota	18 "	Newport News Co.	77.1	80.33
Mississippi	17 "	Wm. Cramp & Sons.	45.74	47.32
Idaho	17 "	Wm. Cramp & Sons.	42.58	45.39
New Hampshire	18 "	New York Shipbuilding Co.	29.2	33.4
ARMORED CRUISERS.				
California	22 knots.	Union Iron Works.	86.2	87.5
South Dakota	22 "	Union Iron Works.	84.9	86.2
Tennessee	22 "	Wm. Cramp & Sons.	90.02	91.66
Washington	22 "	New York Shipbuilding Co.	89.4	91.9
North Carolina	22 "	Newport News Co.	26.77	30.74
Montana	22 "	Newport News Co.	22.29	25.84
SEMI-ARMORED CRUISERS.				
St. Louis	22 knots.	Neafie & Levy Co.	83.62	86.
Milwaukee	22 "	Union Iron Works.	86.	87.9
SCOUT CRUISERS.				
Chester	24 knots.	Bath Iron Works.	13.27	15.53
Birmingham	24 "	Fore River Shipbuilding Co.	15.4	18.2
Salem	24 "	Fore River Shipbuilding Co.	14.8	17.6
SUBMARINE TORPEDO BOATS.				
Submarine No. 9	.....	Fore River Shipbuilding Co.	43.5	46.9
" " 10	.....	Fore River Shipbuilding Co.	36.9	37.8
" " 11	.....	Fore River Shipbuilding Co.	37.	39 9
" " 12	.....	Fore River Shipbuilding Co.	33.6	38.7

Personal.

R. C. Monteagle, who has been connected for several years with the Gas Engine & Power Company and Chas. L. Seabury & Company, Consolidated, has resigned to become chief engineer of the Atlantic Works, East Boston, Mass.

Warren Johnson has resigned his position as manager of the Johnson Iron Works, New Orleans, and has opened offices as a consulting engineer. His address is P. O. Drawer 241, New Orleans, La. He is a graduate of Cornell University in the class of 1897.

THE DETERMINATION OF THE PRINCIPAL DIMENSIONS OF THE STEAM TURBINE, WITH SPECIAL REFERENCE TO MARINE WORK.*

BY E. M. SPEAKMAN.

In designing any turbine installation, the first and most essential step is to estimate the highest suitable speed of rotation in order that the turbine may be made as small as possible for any given efficiency. While there is now no great difficulty in accurately determining the proportions of turbines and propellers to insure certain results, with ample confidence to enable a stiff guarantee to be made both for speed and economy, the principal dimensions involve considerable calculation, and much attention must be devoted to the efficiency of propulsion if the best results are to be obtained. Knowledge of propulsive efficiency and all its component values for various classes of work is essential for calculating propeller dimensions, and thereby arriving at the highest revolutions attainable, for it is only when the rotary speed is settled that the best compromise of turbine dimensions, chiefly in the matter of blading arrangements, can be determined.

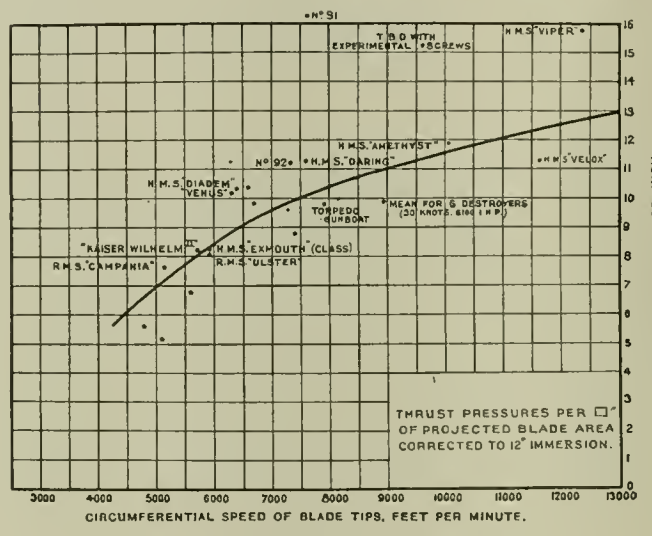


FIG. 1. PRESSURES ON PROPELLER BLADES.

Turbine efficiency and propeller efficiency must be considered separately and also together, because it may be found that the use of revolutions somewhat below the maximum obtainable will increase the combined efficiency, while on the other hand, to obtain certain advantages in weight and space, this efficiency may be slightly sacrificed at the highest speed, and it is necessary to know the effect of such modifications on the design and performance. Roughly, the weight of the turbines will vary inversely as the square of the revolutions, while the economy of the turbine will remain almost constant if designed for the same internal conditions; the efficiency of the propeller will be slightly improved as the revolutions decrease and the diameter is made greater.

In electrical work the design of generators almost invariably admits of very convenient speeds, but in marine work the size of propeller necessary to avoid cavitation imposes a much lower limit, with which the size of the turbine is greatly increased. The minimum size of propeller required to avoid this phenomenon (and its attendant inefficiency due to increased slip and consequent loss of thrust at the higher powers), must be calculated at the beginning of any design, as it is almost impossible to assume certain revolutions and later on to design a propeller to suit.

Cavitation is partly the result of attempting to obtain too much work per square foot of blade area, and partly of excessive

*A paper read October 24, 1905, before the Institution of Engineers and Shipbuilders in Scotland.

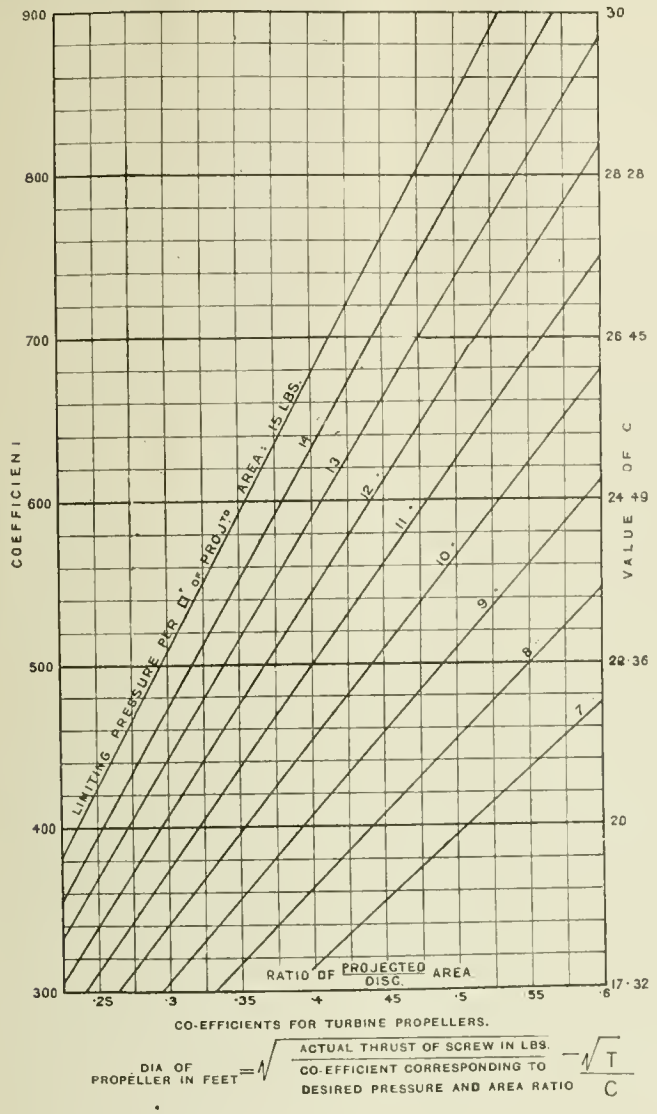


FIG. 2. TO DETERMINE TURBINE PROPELLER DIAMETERS.

peripheral speeds. It has been found, by bitter experience occasionally, that there is a narrow limit to the tensional pressure possible on the water, per unit of projected area, beyond which the propeller efficiency drops very rapidly. This pressure is approximately from 10 to 12 pounds per square inch at a depth of twelve inches below the surface, and to reduce the total thrust to this, sufficient blade area must be provided, which, in conjunction with certain practical proportions, necessitates a certain size of propeller, thereby limiting the revolutions.

Friction and slip constitute the normal losses in all propellers, and augmented resistance must also be taken into account. This latter loss, however, is materially reduced with the smaller diameters of propeller found in turbine work. Comparing the *Manxman* with the *Ulster*—a Holyhead mail boat of similar speed and power—the total disk area of the twin propellers of the latter is 226 square feet (for two 12-feet-diameter propellers), while that of the *Manxman* is only about 80 square feet. If the thrust deduction is proportional to the absolute area of the disturbance of the stream lines at the stern, the effect on the *Ulster* will be far greater than on the *Manxman*, but this action is to some extent affected by the intensity over the disturbing area, which again is modified by the proximity of the propellers to the side of the vessel, this being less in turbine work. The disk area in H.M.S. *Velox* is less than half that of the propellers in ordinary destroyers of the same power and speed. Cavitation is a preventable loss, and its presence on many vessels with insufficient blade area may be deduced from the falling off of the thrust curve and the rapid rise in the slip curve above a certain speed.

From the analysis of numerous trials it appears that the pressure per square inch of projected area, when reduced to twelve inches immersion of tip, due to the effective thrust, is approximately 1 pound for every 1,000 feet per minute of circumferential velocity of blade tips. For a screw of a given pitch ratio, working at its maximum efficiency, this velocity should be proportional to the designed speed of the ship, and at full speed the pressures seem to have hitherto been about 5 pounds per square inch for slow cargo vessels, from 6 to 7 pounds for ocean-going mail steamers, and from 7.5 to 8.5 for cross-Channel steamers; in cruisers and battleships they vary from 8 to 10.5 pounds in some recent notable instances,, and in torpedo craft from 9 to 11 pounds. At about 9 pounds—rather less, possibly—the lowest suitable limit is reached for turbine screws; from 10 to 11 pounds may be more usual in fast vessels, and though even from 12 to 14 pounds has been known, pressures over about 11 pounds always seem to be accompanied by low efficiencies. In large ocean-going vessels, which may be

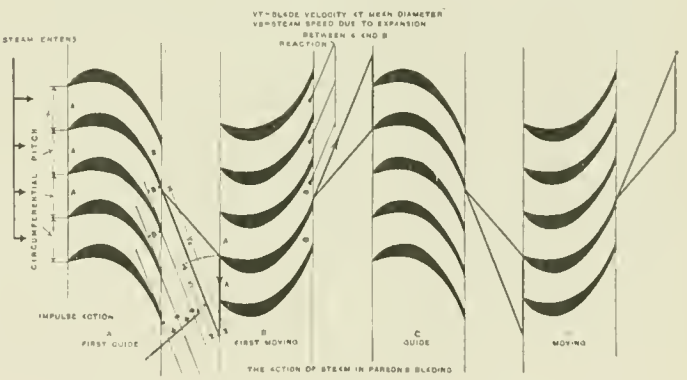


FIG. 4. IMPULSE AND GUIDE BLADE DIAGRAM.

delayed by headwinds and seas, a much lower designing pressure should be used, but in destroyers, as suggested above, something may be sacrificed at the maximum speed to obtain other advantages. The above pressure is worked out as mean pressure, as there exists no method of determining the local intensity per square inch, though the tendency of the distribution may be assumed in some cases. The only published results are in

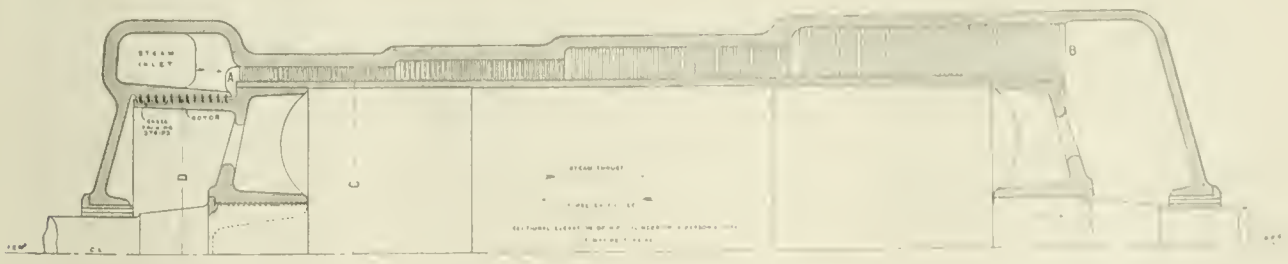


FIG. 3. SECTIONAL ELEVATION OF A PARSONS' MARINE TURBINE.

Barnaby's papers on the trials of H.M.S. *Daring,* but they are very inconclusive in many ways. Fig. 1 is submitted with much diffidence, merely as an illustration of the values of this limiting pressure.

The maximum peripheral speed of tip ever used, I think, was 12,400 feet per minute, in H.M.S. *Viper;* in H.M.S. *Velox* it is about 11,650, and in the *Londonderry* about 11,760; but many vessels have been below 9,000, which is quite normal for ordinary destroyer practice.

The pitch ratio for turbine propellers has been purposely made considerably finer than usual. Thus, the pitch ratio for the *Emerald* was about .6; in Channel steamers and cruisers of from 18 to 25 knots it has varied from .8 to 1, and in torpedo craft from 1 in H.M.S. *Velox* to 1.35 in H.M.S. *Viper,* and 1.6 in H.M.S. *Cobra;* the latter vessels having 1, 2 and 3 screws per shaft respectively, driven by identical turbines, the approximate revolutions at full speed being 900, 1,200 and 1,050, for 27, 36 and 31 knots respectively on trial.

The slip has varied from 23 percent in H. M. S. *Viper* down to about 14 percent in the *Viking*—channel steamers usually having from 17 to 24 percent. For large ocean-going vessels, about 16 to 20 percent may be used with due regard to other considerations of propeller efficiency. The section of the blades should be carefully designed in order to try to obtain a shape that will enable as high a mean pressure as possible to be adopted. Recent experiments in the model tank at Washington, D. C.,* seem to show that a symmetrical section will materially increase the pressure at which cavitation commences, and also demonstrate that in fine-pitch, high-speed screws the back of the blade should receive almost as much attention as the face. This, as the author is well aware, is no new idea, but there have been repeated indications, especially in the trials of ordinary torpedo boat destroyers, that while the gain may not be great, it is sufficient to merit attention. Mr. Parsons has advocated a 10 percent reduction of pitch at the blade tip in order to avoid excessive local thrust, which might induce early cavitation; but there seems to be no advantage in departing from a true screw. The tendency of late years, in reciprocating engine practice, has been to increase the ratio of projected disk area from the .2 of Froude's classic screw and the .22 to .26 of naval practice, to about .33; destroyer practice was included between this and .37, or even .4, at which point turbine practice may be said to commence. In this even from .5 to .56 has been used, but beyond about .58 blade interference becomes excessive, and to obtain greater area a larger diameter must be used.

The best form of blade is still undetermined. Experience seems to show that the almost circular shape, with the area disposed symmetrically on each side of the center line, and with the generating line of the screw at right angles to the axis, gives as good results as any form.

I find that the following formula will give the diameter of a turbine propeller with considerable accuracy when the effective thrust along the shaft is known, and this must be calculated in any case if the steam balance of the turbine is to be good:

$$\text{Diameter of propeller in feet} = \sqrt{\frac{\text{Effective thrust in lbs.}}{\text{Coefficient}}} = \frac{\sqrt{T}}{C}$$

This coefficient has been deduced from the limiting pressure per square inch, and the ratio of projected to disk area, and is given in diagram form in Fig. 2, where the full coefficient 400—900 is given in the left-hand scale, and values of C or $\sqrt{\text{Coefficient}}$ appear in the right-hand margin. The square root is extracted only for simplicity, whereby such coefficients as 30 are obtained for H.M.S. *Viper;* while for the *Manxman* that for the center screw is 26.4 and for the wing screws about 28.75. For large ocean-going vessels with lower designing pressures these values will be rather less, perhaps about 22.

*See D. W. Taylor's paper, Marine Engineering, February, 1905, page 72.

The following table gives a few propeller dimensions and the corresponding coefficients, which the author trusts will be of use in designing high-speed screws:

TABLE I.—PROPELLER DIMENSIONS.

Vessel.	No. of Screws.	Diameter. Ft.	Diameter. Ins.	Pitch. Ft.	Pitch. Ins.	Pitch Ratio.	Speed of Tip.	C (Approximate.)
							Ft. per min	
Turbinia....	9	1	6	2	0	1.33	10,860	28*
	3	2	4	2	4	1	.....	31.3*
Viper.....	8	3	4	4 for'd 4.6 aft.		1.2 1.35	12 350	30.1
Amethyst....	3 (1, 2)	6	6	6 5	6 10	1 .898	9,200 10,000	30 8
Manxman...	3 (1, 2)	6	2	5	7	.906	10,270	26.4
		5	7	5		.896	10,760	28.75
Londonderry	3 (1, 2)	5		4	6	.9	10,550 11,810	30.8
Dieppe.....	3	5	3	...		...	10,100 10,400	29
Carmania ...	3	14		13		.928	8,125	21
Victorian ..	3	8	3	...		....	7,150	24.65

* These C values are calculated from the same effective thrust in each case

Compared with above values of C, reciprocating engine practice gives such figures as: R.M.S. *Lucania,* 16.5; H.M.S. *Diadem* class, 17.5; H.M.S. *Exmouth* class, 19; and standard 30-knot destroyers of 6,100 horsepower, 20.8; all of which have much lower ratios of projected to disk area, and therefore a large diameter and smaller C for a given power. Regarding these figures, it must be understood that C is an approximation only, and, owing to the difficulty of obtaining the actual power in each shaft in every case, cannot be considered as absolutely accurate. Probably, however, the error involved is under 2 percent. It seems likely, to some at present undeterminable extent but within narrow limits for each class of vessel, that the propeller efficiency is proportional to the coefficient C, and this seems to be borne out by the trials of the *Manxman* and the *Londonderry.*

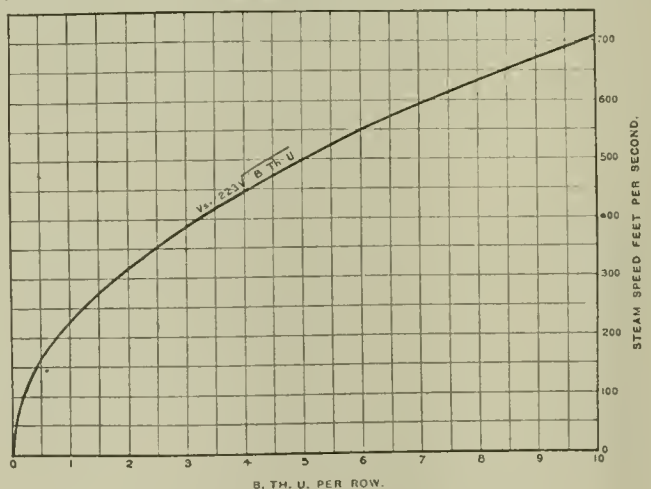


FIG. 5. DETERMINATION OF NUMBER OF ROWS OF BLADES.

Effective thrust is a somewhat subtle subject, and our knowledge of propulsive efficiency is by no means what it ought to be. These considerations will undoubtedly be brought into far greater prominence in the near future, and it is by no means improbable that the Admiralty or certain private owners will require some definite standard in this, just as coal or steam consumption is regulated at present. The more propeller efficiency is studied and understood the greater will be the improvement in the design of turbine installations for marine work; the turbine itself is a comparatively secondary consideration, and while at present propeller dimensions for turbine steamers can be quite as closely determined as those for ordinary work, the exact proportions must necessarily remain largely subject to modification from actual experience.

While a general tendency has been very noticeable toward increasing the propeller diameter and reducing the revolutions, there will of course be some point, at present undetermined, at which the triple screws used in turbine work will be distinctly less efficient than ordinary twin screws. Very largely, this is the case at present with triple screws, driven by piston engines, on account of excessive thrust deduction and interference, but probably before this point is reached the weight of the turbines will have prevented its adoption.

Having obtained the diameter of the propeller and the revolutions possible, the design of the turbine can then be undertaken, but for this no formulæ exist at present, such as are met with in reciprocating engine practice.

Restricting attention to the design of the Parsons type of turbine, a few notes on the action of the steam among the blades may be of interest. Expanding through a definite range of temperature and pressure, steam exerts the same energy, whether it issues from a suitable orifice or expands against a receding piston. Two transformations of energy take place in the steam turbine—first, from thermal to kinetic energy; secondly, from kinetic energy to useful work. The latter alone presents an analogy to the hydraulic turbine, the radical difference between the two lying in the low density of steam compared with water, and the wide variation of its volume under different temperatures and pressures.

Fig. 3 gives a sectional elevation of a marine turbine blading arrangement, and though this is only for a high-pressure cylinder the principle is exactly the same throughout. The expansion, which is approximately adiabatic, is carried out in this annular chamber from A to B, which essentially resembles a simple divergent steam nozzle, but with this difference, that whereas in a nozzle the heat energy of the working steam is expended upon itself in producing high velocities, in Parsons' turbine the total expansion is subdivided into a number of steps, in each of which a certain dynamic relationship between jet and vane is maintained. The expansion of steam at any one stage is typical of its working throughout the turbine. Each stage consists of a ring of stationary blades which give direction and velocity to the steam, and a ring of moving blades that immediately convert the energy of velocity into useful torque. The total torque on the shaft is due to the impulse of steam entering the moving blades and to reaction as it leaves them, this process being repeated throughout the turbine.

Leakage past the revolving portion of the spindle at D is almost entirely prevented by the ingenious form of frictionless packing. The fine clearances and the sudden increase of section have the effect of alternately wire-drawing and expanding the steam, so that at successive grooves it becomes increasingly difficult for the steam to leak past the clearances. In the astern turbines, a radial form of packing, depending on fine tip clearances, must be adopted, owing to the difference in expansion between spindle and cylinder. Numerous varieties of these forms of packing exist, some of them being extremely efficient in their action.

The laws governing the best theoretical velocity of steam and blades are similar to those for water turbines, but in practice some modification is necessary, and the best ratio of blade speed and steam speed is still a matter of opinion. The ideal condition for impulse turbines occurs when the peripheral velocity of the buckets is one-half that of the jet, or in reaction turbines, when it is equal to it.

Parsons' turbines, however, have been built with Vt, Fig. 4, varying from .25 to .85 of Vs, where Vt represents blade velocity at mean diameter, and Vs the steam speed due to expansion across the row in question. A very usual ratio in electrical work for large units has been $\frac{Vt}{Vs} = 0.6$; but this involves a greater number of rows than is possible in marine work, and the ratio must be reduced. These ratios need very careful calculation. The steam consumption must be accurately known in order to proportion them correctly throughout the turbine, and the necessity (which is inevitable with the present form of calking piece) of having the same area of openings in so many rows while the steam volume increases so rapidly that it adds to the difficulty of close calculation. The potential energy of the steam, corresponding to the "head" in water turbines, can easily be calculated for given pressure differences.

$$B.\,T.\,U. \times 778 = \text{Energy in foot lbs. per lb. of steam} = e.$$

$$Vs = 8 \vee e = 223 \vee B.\,T.\,U.$$

For a given blade velocity, it is obvious, then, that the speed ratio between jet and vane must affect the number of stages, and the greater the ratio of Vt to Vs the greater will be the required number of rows; that is, to obtain the required Vs at each stage a smaller pressure drop per row is necessary, or *vice versa*.

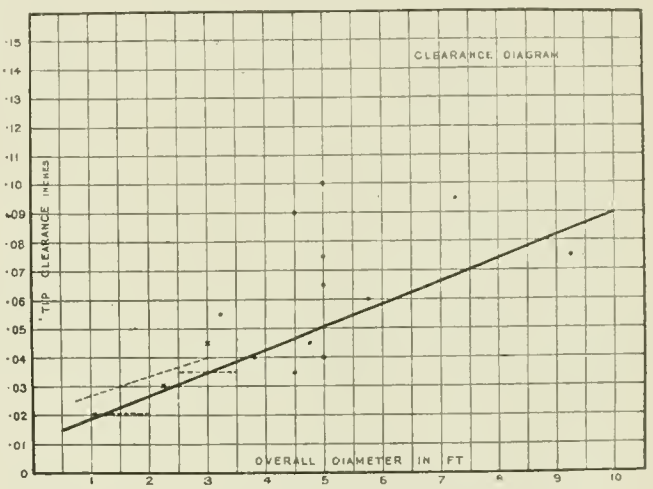


FIG. 6. DIAGRAM OF CLEARANCES AT TIP OF BLADES.

The best blading arrangement, scientifically and commercially, is the result of much theory and practice. The mean diameter is an arbitrary dimension, capable of wide variation without affecting the efficiency, provided that the number of rows is correct; it is found by assuming, from experience, a blade velocity, whence—

$$\text{Mean diameter in inches} = \frac{\text{Blade velocity in feet per sec.} \times 228}{\text{R. P. M.}}$$

To arrive at the corresponding number of rows, the revolutions being given, the ratio of Vt to Vs must be settled, from which the steam speed can be obtained; it is a convenient assumption at the beginning of any design to consider the turbine as parallel throughout and of constant efficiency, and to design on this basis. The number of rows N on one diameter can be found by working out the B. T. U. necessary to give a certain steam speed at each row (see Fig. 5). The available energy divided by the energy it is desired to abstract at each row will give the number of rows required. This result may be arrived at by various ways, but the principle involved is the same in each case. Numerous empirical coefficients for approximating steam speeds and the corresponding number of rows are obtainable from experience, and are similar in use and value to the Admiralty coefficient; that is, while they represent a crude method of doing something that should be done more scientifically, they are very simple and capable of rapid handling. Being, however, based on long and costly experiments, much reticence is observed regarding their publication. Varying, of course, with the steam pressure and vacuum, the number of rows on one diameter would involve an excessive length of turbine and also inconvenient

blade heights. It is, therefore, usual to divide the rotor into three or more stages, which have the advantage of shortening the turbine and reducing the number of rows. If n = the fraction of power developed in the first cylinder or barrel, $\frac{N}{n}$ = number of rows in the first barrel, and with the alteration of diameter and increase of blade velocity in the succeeding stages, the number of rows on other barrels is so altered as to keep, for equal powers and efficiencies:

$$(\text{Blade velocity})^2 \times \text{No. of rows} = \text{Constant.}$$

The vane speeds adopted in practice vary considerably; for some time 100 feet per second was regarded as a standard for the first row, and I think the Westinghouse Company at Pittsburg was first to make a radical departure in this and adopt far higher speeds. The maximum vane speed used for Parsons' blading is, as far as the author is aware, about 375 feet per second in the low-pressure blades, and 170 in the high-pressure blades of electrical turbines; the lowest speeds used are in marine work, and are only about one-third of these. To some extent blade speed is governed by blade height; the speed should be so modified that this may be at least three percent of the mean diameter, to reduce the proportion of clearance losses. Leakage over the tips of the blades is perhaps not so detrimental on account of actual leakage loss as in its superheating effect on steam between the row past which it leaks and the last row, because this reheating effect upsets calculations regarding openings by increasing the steam volume, and thereby affects the fluid efficiency. This leakage over the tips must be taken into account in designing reaction turbines. Temperature and diameter influence the clearance, and the stiffer the cylinder is to resist distortion due to heat the less it may be made. A clearance diagram based on measurements off a large number of machines is given in Fig. 6.

In Table II, the vane speeds adopted in various classes of work are given, and the reduction in peripheral speed on account of the propeller reducing the revolutions, and the necessary proportion of blade height modifying the diameter may be clearly seen. To this combined action is due the fact that only in the faster classes of vessels, or in those small types in which some propulsive efficiency can be sacrificed, is the turbine applicable. In slow cargo steamers, though the revolutions may be high enough, the power required is not sufficient to enable a reasonable blade height to be adopted, and it is this consideration, viz., proportion of leakage over blade tips—that curtails the wider adoption of this type of turbine. For the same low peripheral blade speed, other types of turbine are unsuitable on account of the impossibility of reducing the steam velocity sufficiently without abnormal weight and inefficiency.

Type of Vessel.	Peripheral Vane Speed. H. P.	Peripheral Vane Speed. L. P.	Mean Ratio of $V_t \div V_s$.	Number of Shafts.
High speed mail steamers....	70- 80	110-130	.45 to .5	4
Intermediate mail steamers...	80- 90	110-135	.47 to .5	3 or 4
Channel steamers.....	90-105	120-150	.37 to .47	3
Battleships and large cruisers.	85-100	115-135	.48 to .52	4
Small cruisers..	105-120	130-160	.47 to .5	3 or 4
Torpedo craft.....	110-130	160-210	.47 to .51	3 or 4

The smallest size of marine turbine is usually larger than the average electrical turbine as far as power is concerned, and therefore does not meet with the same commercial considerations as the smaller sizes of the latter type. These are not designed for the same internal efficiency as the larger machines, chiefly on account of manufacturing cost, and they do not attain anything like the same efficiency compared with the Rankine cycle

Speaking in reply to the discussion on his paper to the Institution of Naval Architects in 1903, Mr. Parsons said that "for all practical purposes, while the steam is traversing each set of blades as shown it behaves like an incompressible fluid, just like water would do, as the expansion is very small at each set. The frictional losses and the eddy-making losses would be practically identical within small limits with what they would be with water, and the actual forces would be in proportion to the density of the medium. * * * In the turbine blades themselves the efficiency is between 70 and 80 percent."

Using this hydraulic analogy enables us to calculate the number of stages required in a different manner; the "equivalent head," due to the steam pressure, may be found, together with that at each row necessary to give the required velocity, from which both the number of stages and the coefficient of expansion at each stage may be worked out.

In the early marine designs, such as the *Queen Alexandra* and H.M.S. *Amethyst*, the turbine drums were all made of the same diameter, and the higher speed necessary on the low pressures was got by running at considerably higher revolutions than on the high pressure shaft; but, following up the increase in propeller efficiency found to be due to the use of larger screws, the speed for each shaft is now more nearly equal, while the wing drums are made larger in diameter. The vagaries of the following wake, however, necessitate slightly different propeller dimensions on each shaft, or else slightly different revolutions with the same screws; and it is noticeable in a triple-screw arrangement, the center screw being right-handed and the wing screws revolving outward, that the starboard propeller is influenced by the center one, and almost invariably revolves at a lower speed. In a four-shaft design, due to the varying wake values at different speeds, and possibly, also, to some unequal distribution of power, the outer screws run slower at low speeds and faster at high speeds than the two inner shafts, but exact data as to this, and the possibility of allowing for it in the design, are still wanting.

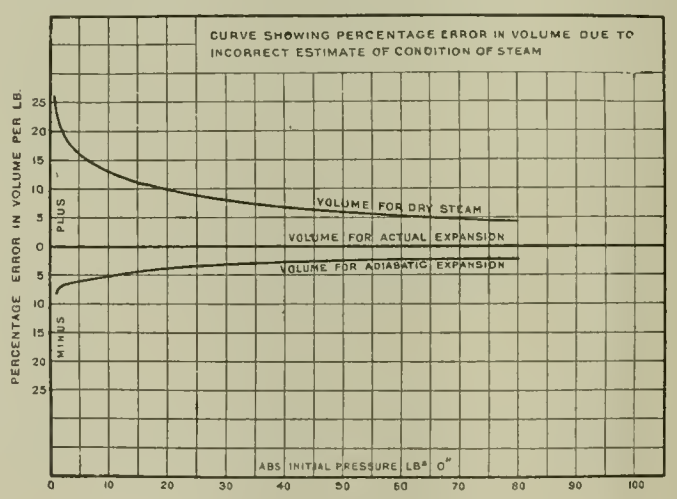

CURVE SHOWING PERCENTAGE ERROR IN VOLUME DUE TO INCORRECT ESTIMATE OF CONDITION OF STEAM
PERCENTAGE ERROR IN VOLUME PER LB.
PLUS
MINUS
VOLUME FOR DRY STEAM
VOLUME FOR ACTUAL EXPANSION
VOLUME FOR ADIABATIC EXPANSION
ABS INITIAL PRESSURE LB^a 0"
0 10 20 30 40 50 60 70 80 90 100
25 20 15 10 5 0 5 10 15 20 25

FIG. 7. CORRECTION FACTORS FOR CONDITION OF STEAM.

In all types of turbines—Parsons, Rateau, Curtis, etc.—a certain ratio must be maintained between the blade velocity and steam velocity; and as steam acquires very high velocities by expansion, the blade velocity must be maintained either by the revolutions or by large diameters, or both. As the weight increases very rapidly with the diameter, and extraordinarily so with the reduction in rotative speed, it is preferable to increase, if possible, the revolutions or the number of stages rather than the diameter, and especially should this be done in cases where, as in the Rateau or Zoelly types, the weight increases more rapidly in inverse proportion to the revolutions per minute and the diameter than it does with other types. To increase the revolutions, it may be necessary to increase the number of shafts and propellers, thus reducing the power per shaft and the effective

thrust through each screw. Increasing the diameter of the turbine adds largely to the constructional difficulties, especially of the cylinder.

Having obtained the number of rows and the diameter, the blading arrangement can be worked out in detail. The height of blade depends on the volume of steam and the speed at which it is to flow, and also on the ratio of the area of exit openings between the blades to that of the annulus between spindle and cylinder, which is about one-third in normal blades. The necessary clear area to pass the steam being equal to volume ÷ velocity, and knowing this annular factor, say 3, for a ratio of one-third (or 2 for ½, etc.), then—

$$\text{Height of blade in inches} = \frac{\text{Clear area in square inches} \times 3.}{\text{Mean circumference in inches.}}$$

The ratio of blade height to mean diameter should not be less than 3 percent or more than 15 percent, because in the former the leakage will be excessive, and in the latter the bending moment on the blade becomes too great, and the radial divergence of the blades too much. The width of blade, the shape of section adopted, and the circumferential pitch, are standard considerations, and affect the factor 3 given above. It is not proposed to enlarge upon them in this paper. It may, however, be remarked that for $\frac{Vt}{Vs}$ greater than .6 the usual shape of Parsons' section as shown in Fig. 3 should be modified to a somewhat different form of blade, with a sharper entrance edge. This section is not to be recommended, as, owing to the necessity of strengthening the blade sufficiently, the metal must be placed nearer the exit edge, thus increasing the angle between the face and the back of the exit edge of the blades, and giving, in fact, an inferior shape of opening compared with that obtainable with a blade section adapted to ratios under .6. While the axial spacing must be kept down to reduce the length of drum, it must be sufficient to allow for some play in overhauling, and sufficient clearance can be allowed here without affecting the economy. The openings between the blades to allow of the passage of the steam are very important, and must be carefully designed. The actual volume of the steam—not the volume per pound, as found in tables, or the volume due to adiabatic expansion, but the exact volume per pound at any point along the turbine—must be determined, in order to arrive at the desired adjustment of velocities. It is extremely doubtful whether the present blading arrangements give the best results; greater accuracy of calculation and consequently improved pressure distribution and efficiency seem likely to follow the use of a more mechanical blading construction.

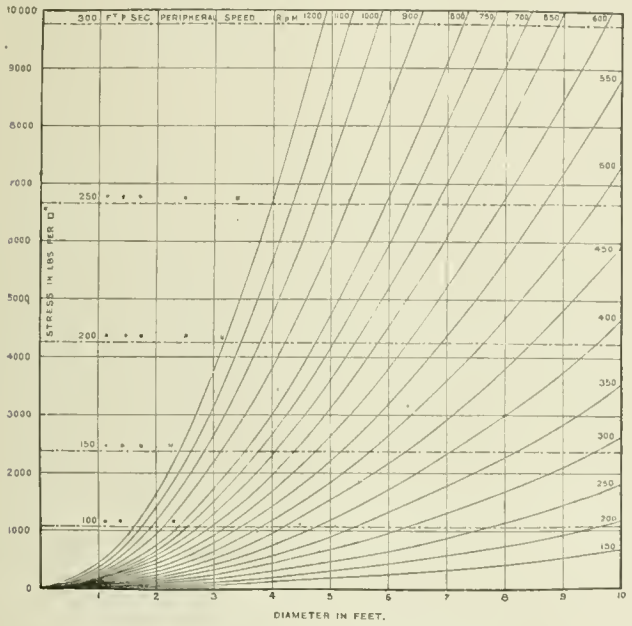


FIG. 8. STRESSES DUE TO CENTRIFUGAL FORCE.

Fig. 7 shows the percentage error involved in using either the dry volume or that due to adiabatic expansion, compared with the correct volume corresponding to the actual expansion in a large turbine using dry saturated steam at the first row of blades and 27 inches vacuum. Attention must be paid to the effect of approximately adiabatic expansion and the consequent moisture in the steam.

For manufacturing convenience, as well as to allow for the expansion of the steam, the blade heights are stepped up, but no rule exists for this; the blades might be of one or of sixty-four heights, provided the blade openings are correct. It is, however, convenient to step them, as in Fig. 3, say, in 8 steps of 8 each, or 4 of 16—even 9 of 7 would do—and so avoid any great variation from the annular area factor 3 as shown above. To obtain heights and areas, it is best to plot off, graphically, volumes, steam speeds, and clear areas required. The use of standard blade heights will then enable the number of stages and rows per stage to be determined; wide differences can be made in

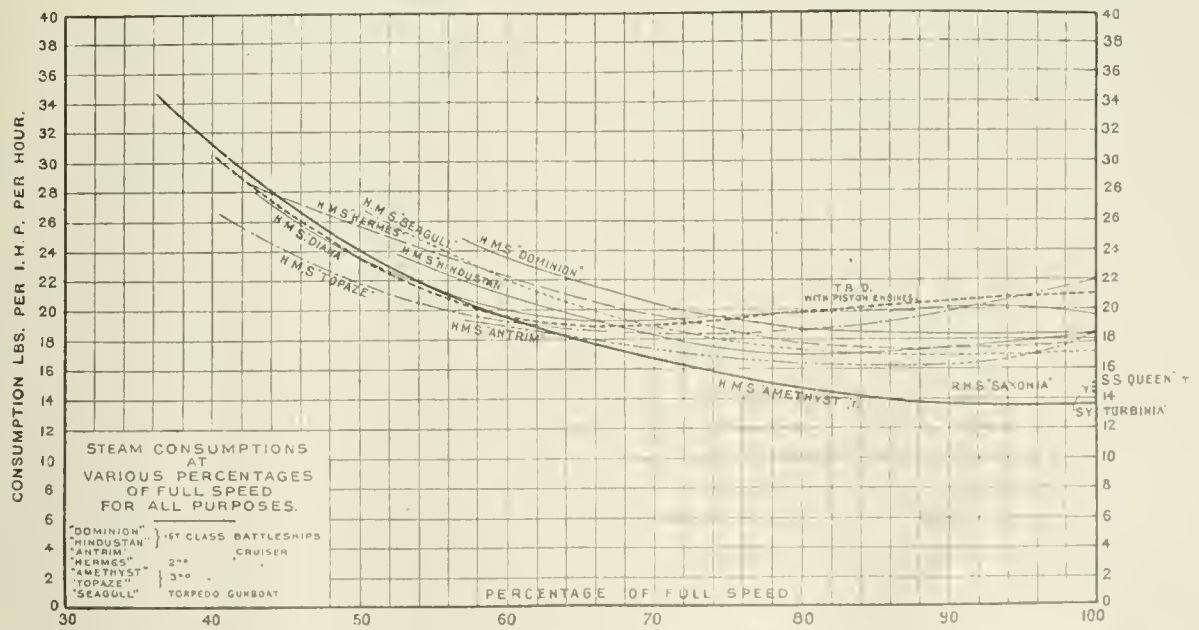


FIG. 9. STEAM CONSUMPTION OF VARIOUS SHIPS PER INDICATED HORSEPOWER PER HOUR.

any arrangement without materially affecting the economy. The best arrangement is largely a matter of convenience and experience.

The material of which blades are usually made is a mixture of cheap brass containing about 16 percent of copper and 3 percent of tin. Alloys containing zinc are extremely unreliable for high temperatures, but blades containing about 98 percent of copper have been found very satisfactory for use with high superheats. More recently a material containing about 80 percent of copper and 20 percent of nickel has been adopted, and this is undoubtedly the best blading material existing. Steel blading, drawn in the same way as the usual brass section, has been used in the United States with fairly good results. The process of drawing turbine blades gives an extremely tough skin to the metal used, not only increasing the tensile strength, but greatly decreasing the chances of erosion.

It seems probable that the usual calking piece now adopted will be discarded in favor of a machine-divided strip into which the blades may be fitted, and instead of the slotting, wiring, lacing, and soldering process at the tip, a similarly machine-divided shroud will be used, giving a far stronger construction, and enabling finer clearances and better workmanship to be obtained, at the same time considerably reducing the cost of manufacture and the risk of blade stripping.

The chief causes of the latter may be set down to bad workmanship in fixing the blades, defective blade material, excessive cylinder distortion (this is probably the most fruitful cause, and is a serious one, being due to bad design), whipping of turbine spindles (which is also due to bad design, or bad balancing), wear of bearings (which is very remote), and the introduction of extraneous substances such as water or grit. In fact, blade stripping may be said to generally occur from preventible causes.

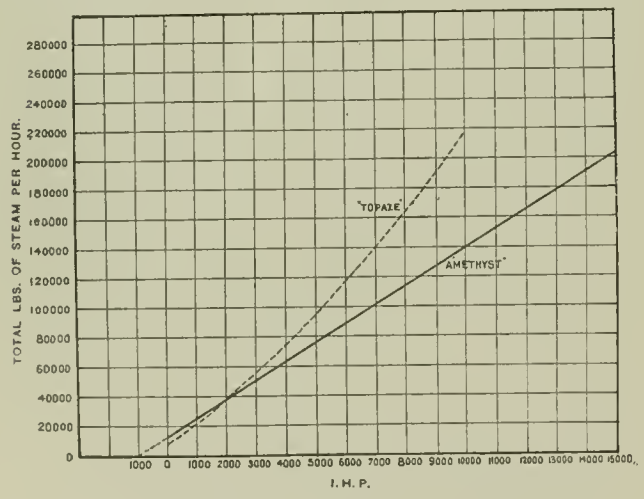


FIG. 10. TOTAL STEAM CONSUMPTION AT VARIOUS POWERS.

Small vibrations of very high frequency occasionally set up an action in certain rows of responsive length that fatigues the blade material and causes the loss of blades without any fouling at all.*

Due to the action of the steam, an end thrust occurs in the direction of the propeller, which is advantageously used in partially balancing the propeller thrust, thereby reducing the size of thrust block necessary. A margin must be allowed here, and the propeller thrust is not entirely balanced by the pressure on the annulus between the dummy-ring diameter *D*, and the spindle, Fig. 3, *C*, plus the end pressure on the blades. For the diameter *D* to give the required annulus the effective thrust, as well as that of the propeller, must be carefully calculated; and experience shows that there is a drop in steam pressure varying from 10 to 15 pounds per square inch between the pipe inlet to the high-pressure receiver and the first row of blades, which should be considered in designing this balancing area. The number of rows of dummy packing used varies according to the designer's judgment very largely, and may be modified according to the pressure and the clearance allowed—say 7-1000 to 15-1000 of an inch in electrical work and rather more in marine work.

The dimensions of the astern turbine are arrived at in the same manner as those of the ahead, the efficiency being largely sacrificed on account of weight and space; generally, the mean diameter is made practically the same as that of the high-pressure drum.

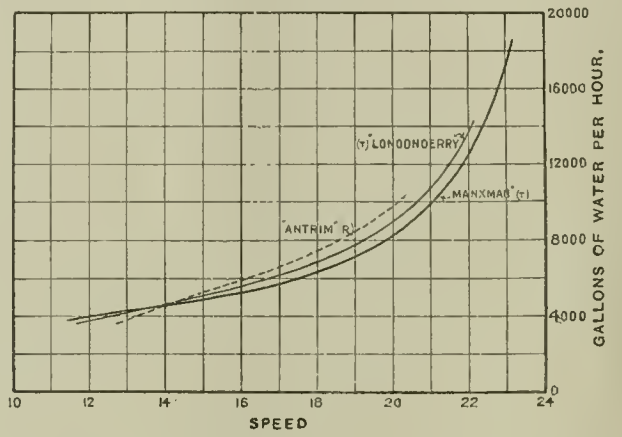


FIG. 11. STEAM CONSUMPTION OF MIDLAND STEAMERS.

To a large extent, the inferior maneuvering capabilities of the earlier turbine steamers were due to insufficient astern power.

It may be remembered that in a marine turbine the spindle is in compression and the cylinder in tension when working. In electrical turbines where the end thrust must be eliminated by the use of balancing pistons, the spindle is in tension and the cylinder is balanced. The shafts between the turbine bearings and the drum must be made amply stiff enough, as well as strong enough, for any sag in the spindle will destroy the clearance. As will be seen from Fig. 8, the stresses due to centrifugal force are very low in the Parsons turbine, and except in occasional low-pressure barrels do not exceed about 7,500 pounds per square inch, while at the high-pressure end they are usually under 2,000.

The pressure on the bearings in a turbine is due only to the weight of the spindle, plus the negligible addition in marine work of that due to any gyroscopic action; it may be taken as from 80 to 90 pounds per square inch as long as the rubbing velocity does not exceed 30 feet per second. If it does, the pressure must be reduced so that the product of pressure × velocity does not exceed 2,500 or 2,700. In land work, 50 pounds × 50 feet is very common. The friction heat of the bearings added to that due to conduction through the pedestals necessitates the use of large oil coolers, and in the case of very high temperatures, of special kinds of oil. If possible, the bearing temperature should not exceed from 140 degrees to 150 degrees F., though the writer has known of 190 degrees F. being used without trouble. In marine turbines this temperature is usually much lower. Rigid bearings are used for marine spindles, not the flexible type adopted in land work.

Space does not permit of more than passing reference to cylinders; but it would be difficult to exaggerate the importance of very careful design in this connection. Cylinders with heavy flanges on the center line distort in a very curious fashion when heated with their axis horizontal, and measurements taken off a hot cylinder on a surface plate with micrometer gauges reveal some very remarkable facts. When working, the temperature along the cylinder falls possibly from 400 degrees to 100 degrees F. in a distance of 6 or 8 feet, and, unlike the reciprocating

*The writer had experience of this early in 1905 when a 5,000-K.W. turbine, under test in one of the large New York power stations, shed several rows of blades. This difficulty has also occurred in Europe, and can be circumvented by an alteration in the position of the lacing strip.

engine, this remains constant; the radial expansion is consequently more at one end than at the other; while at any point along the turbine the tendency is to expand less at the flanges than at the top and bottom. For this reason ample clearance must be allowed; exactly what this will be when spindle and cylinder are hot is hard to say, but it seems most likely that the total clearance area will differ but little from what it is when cold.

The longitudinal expansion when hot is often very marked, and in all turbines necessitates provision for the resultant movement at one end. In marine work the after end of the cylinder is secured to the vessel, the engine seating also performing the function of a thrust-block seat, while the forward end slides forward, taking with it the entire shafting. The thrust block is at the

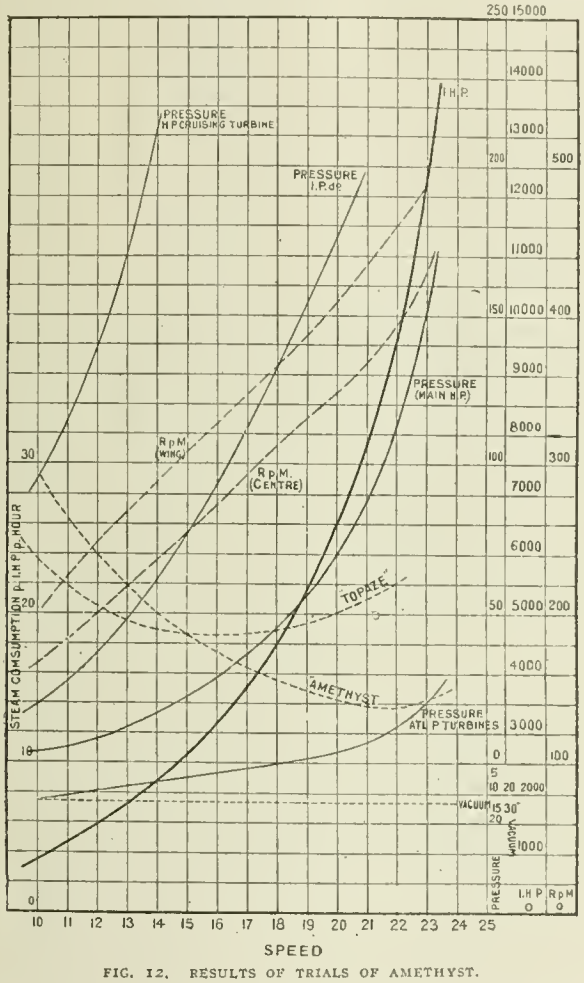


FIG. 12. RESULTS OF TRIALS OF AMETHYST.

forward end of the cylinder, and also performs the duties of an adjustment block for setting the longitudinal clearances, to do which generally necessitates uncoupling the shafting abaft the turbine.

The difference in expansion between the cylinder and spindle, from the thrust block to the dummy ring, may be the cause of serious difficulties in large marine turbines, unless the closest attention is paid to this feature in the design; and "warming up" with these large cylinders needs possibly even more care than is essential with large piston engines.

On shipboard the turbine cylinders are practically under one's feet, and the radiation from them is very unpleasant, especially if there is any leakage from the glands. To all who are responsible for the lagging of cylinders and the system of ventilation in turbine engine rooms I would call attention to the possibility of their having to stand a watch of 4 or 6 hours on the top of the high-pressure cylinder, such as is the case in the *Eden* or *Amethyst*, the heat in the latter vessel being almost unbearable. With reciprocating engines one stands on a comparatively cool lower platform with the cylinders overhead, and with some chance of the hot gases rising clear, but in naval turbine work under a low deck this point has not met with adequate attention.

In the course of operation, more especially in marine work where no superheaters are used, there is a distinct tendency for the turbine to be supplied with wet steam, the effect of which on the economy is very marked. Experiments that have been made show that the percentage increase in consumption is about twice that of the moisture in the steam. For instance, with 2 percent of moisture in the steam at the first row, the consumption is increased about 4 percent.

A considerable amount of data on the performance of turbines compared with reciprocating engines for marine work is now available. The Admiralty has had tested both cruisers and torpedo-boat destroyers, exactly similar but for their engines and propellers, and trials of the Midland Railway Company's steamers and other cross-Channel boats have corroborated the results regarding economy obtained from the naval vessels. In Fig. 9 is given the steam consumption per unit of power of H.M.S. *Amethyst** compared with that of several recent warships, and it is noticeable that only below from 55 to 60 percent of their full speed does the consumption of the turbine exceed that of the piston engines. Very seldom do vessels steam below these speeds. Cruisers carrying relief crews to the China or Australian stations usually proceed at about 60 percent of full speed, and in the Atlantic maneuvers of 1903 nearly 80 percent of full speed was maintained by the large fleets, while the Japanese battleships built in England made their first voyage to Japan at about 54 percent of their full speed; at which ratio the consumption per indicated horsepower of both the *Hindustan* and *Dominion*, representing very recent battleship construction by eminent builders, is materially in excess of that of the first installation of warship turbines (not including the destroyers). The total consumption of H.M.S. *Amethyst* and *Topaze*, plotted on a base of power, is given in Fig. 10, while Fig. 11 shows same for the Midland Railway boats.† The progressive trials of H. M. S. *Amethyst* are shown in Fig. 12, and, in view of the results obtained from these various vessels, the wholesale adoption of turbine machinery in the royal navy is not surprising.

It is probable that the adoption of cruising turbines will be discontinued before long, and this view seems to be corroborated by the consumption trials of the Midland Railway steamers. Down to 60 percent of her full speed the *Manxman* required less water than the highly efficient *Antrim;* and with a different blading arrangement in the main turbines such a result could be equaled, if not improved on, in war vessels. The additional complication involved with two cruising turbines and their accompanying leakage and receiver losses, together with a considerable increase in weight and space occupied, largely modifies any advantages obtainable in the way of reduced consumption at lower powers. An improved (and easily obtainable) design of main turbine blading should give a better result at the highest powers, practically the same at intermediate powers (as in the case of H.M.S. *Amethyst*, from 14 to 20 knots), and only slightly inferior at speeds below 14 knots; while it will undoubtedly admit of greater ease of handling and be much simpler. In a triple-shaft arrangement the unequal distribution of power on the wing shafts, due to the use of cruising turbines, is a distinct disadvantage: the fluctuation in rotative speed, due to shutting off the high-pressure cruising turbine, may be seen from the trials of H.M.S. *Amethyst*.

*Since the above-mentioned results were obtained, the steam piping has been altered so as to permit the auxiliary exhaust steam to pass through the main low-pressure turbines when desired. This arrangement considerably decreases the consumption at low speeds, bringing the *Amethyst's* consumption below that of her sister ships down to ten knots, or about 45 percent of full speed.

† Fig. 11 is compiled from the results given in Mr. Gray's paper to the Institution of Naval Architects, July, 1905.

In conclusion, the writer would remark that it is impossible in the scope of a paper such as this to touch more than lightly on a subject which is of such vast importance. Many of the points dealt with above, such as cavitation, blading, cylinder design, etc., would require a volume to describe. While turbines, perhaps, are still in their infancy, they are already largely supplanting the reciprocating engine in many types of vessel. The next few years will undoubtedly show as great an improvement as has taken place since the advent of the *King Edward*, barely five years ago, the more especially as the subject will, henceforward, be engaging the attention of all engineers instead of a few specialists; and that this improvement will more than justify the policy of the Admiralty and of the Cunard Company is already certain.

EXPERIMENTAL RESEARCHES ON THE PERFORMANCE OF SCREW PROPELLERS. *

BY W. F. DURAND.

In the fall of 1897 a preliminary paper on this subject was read before the Society, giving the results of certain tests made on a series of seven model propellers, all of the same pitch ratio and form of blade, but with varying widths, thus giving a series with area ratio varying between the limits of .18 and .72. Further prosecution of the work was delayed by various causes, but at length it became possible under much improved conditions in the canal of the hydraulic laboratory of Cornell University, and during the past two years, through the aid of a grant from the Carnegie Institution of Washington, D. C., the work has been carried forward in the intervals of other duties of the observers and other uses of the canal. At the present time the original program (including the examination of several series similar to that first reported on and with selected pitch ratios covering the field of normal design) has been completed, together with certain special and auxiliary investigations not coming within the scope of the present report. The propellers used in the first investigation have also been included in the general program carried out with the improved means made possible by the experimental canal, so that the present report covers in effect the performance of 49 model propellers distributed over the field of pitch and area ratios, as shown by the following table:

PITCH RATIOS.

Area Number.		.9	1.1	1.3	1.5	1.7	1.9	2.1
2	Area Ratio.	.18	.18	.18	.18	.18	.18	.18
3		.27	.27	.27	.27	.27	.27	.27
4		.36	.36	.36	.36	.36	.36	.36
5		.45	.45	.45	.45	.45	.45	.45
6		.54	.54	.54	.54	.54	.54	.54
7		.63	.63	.63	.63	.63	.63	.63
8		.72	.72	.72	.72	.72	.72	.72

The diameter of all propellers was 12 inches and the diameter of the hub 2.4 inches. The shape of all blades was elliptical, the maximum width in tenths of the radius being expressed by the area number in the table.

The experiments were carried out in the canal of the hydraulic laboratory at Cornell University. This canal or tank is about 340 feet in length by 16 feet in width and 10 feet in depth. The canal is provided with water from the reservoir above, through double shut-off gates and an intermediate lock or measuring chamber. Once filled the water is quiescent, and the level may be maintained where desired by an adjustable weir at the western end.

*Read at the thirteenth general meeting of the Society of Naval Architects and Marine Engineers, November 16, 1905.

The principal items of the equipment of this canal are as follows:

(1) A carriage or truck spanning the canal and carrying the propellers to be tested and the apparatus required, and running on a track extending the length of the canal.

(2) A transmission dynamometer for the measurement of the power absorbed by the propeller.

(3) Means for driving the propeller through the dynamometer at speeds varying over a wide range, and for any run in constant proportion to the speed of the truck along the rails.

(4) A thrust dynamometer for measuring the thrust developed.

(5) Means for registering time, distance and revolutions.

GENERAL DISCUSSION.

For the discussion of the results we shall use the following notation:

T = thrust.
Q = torque or turning moment = work $\div 2\pi N$.
d = diameter of propeller.
p = pitch of propeller.
N = revolutions per minute.
s = slip ratio.
u = speed in feet per minute = $pN(1-s)$.
e = efficiency.
a = factor in expression for thrust which depends on slip ratio.
b = factor in expression for thrust which depends on pitch ratio.
c = factor in expression for thrust which depends on area ratio.
x = factor in expression for torque which depends on slip ratio.
y = factor in expression for torque which depends on pitch ratio.
z = factor in expression for torque which depends on area ratio.

Then quite independent of the details of propeller theory we may put

$$T = d^2 (pN)^2 \times abc = d^2p^2N^2abc, \quad \ldots\ldots\ldots\ldots (1)$$

$$Q = d^2 \quad (pN)^2 \times xyz \div N = d^2p^3N^2xyz. \quad \ldots\ldots\ldots (2)$$

Equation (1) is simply equivalent to the statement that the thrust developed by a propeller will vary with the square of the

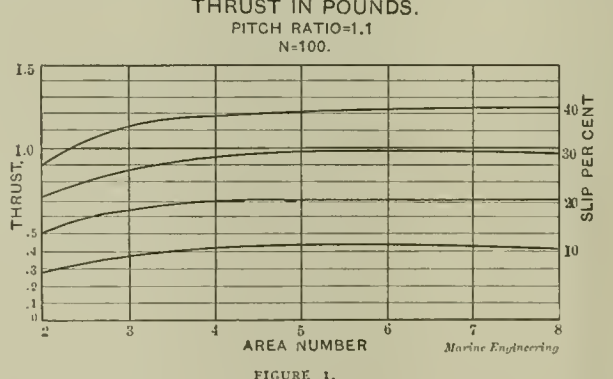


FIGURE 1.

diameter and with the square of the speed, and that it will depend on the slip, pitch ratio and area ratio. The performance will furthermore depend in chief measure on the shape of the blade and on the amount and distribution of the thickness. Since, however, the present experiments provide no means of analyzing out any such influence factors, they must be considered as constant, corresponding to the uniform elliptical shape of the blades and to the standard schedule of thickness employed. In other words, the three items in these experiments which were subjected to determinate control, and which must, therefore, serve as the variables in terms of which the results may be expressed, are slip, pitch ratio, and area ratio. The formulation of (1) expresses, therefore, in algebraic language the universally accepted relation of thrust to diameter and speed, together with the general fact of dependence on these three variable items, through the factors represented by a, b, and c.

In a similar manner (2) is equivalent to the statement that

the work absorbed by the propeller will vary as the square of the diameter and as the cube of the speed, and that it will be dependent also on slip, pitch ratio, and area ratio; and, furthermore, that torque varies as the work divided by the revolutions.

We then have:

$$T \times pN\,(1-s) = \text{useful work} \quad \ldots\ldots (3)$$

$$Q \times 2\pi N = \text{total work} \quad \ldots\ldots (4)$$

$$e = \frac{TpN\,(1-s)}{2\pi QN} = \frac{Tp\,(1-s)}{2\pi Q}$$

or

$$e = \frac{(1-s)\,abc}{2\pi xyz}.$$

Thus far the equations deduced are general. Next, to apply them to the present case, we shall take 100 r. p. m. as a standard

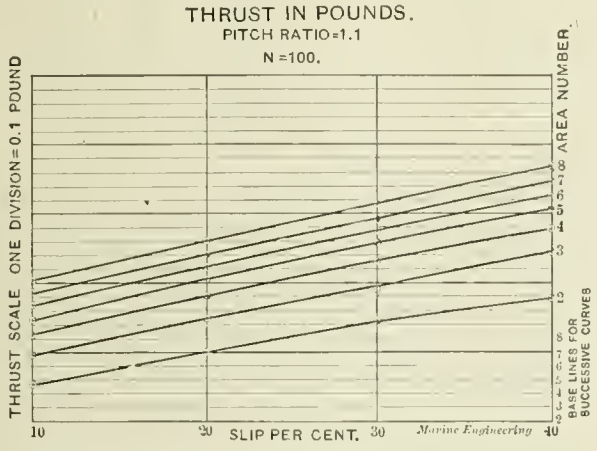


FIGURE 2.

or unit number of revolutions. Then, remembering that d in all cases equals one foot, we shall have in (1) and (2) for the standard revolutions:

$$T = p^2abc. \quad \ldots\ldots (7)$$

$$Q = p^3xyz. \quad \ldots\ldots (8)$$

Now equations (1) and (2) show that for fixed values of d, p, a, b, c, x, y, and z (that is for a given propeller at fixed value of the slip) T and Q will vary as N^2, and hence the actual observations which were made at revolutions varying from 200 to 600 may be reduced to the standard revolutions by dividing by the square of the r. p. m. expressed in units of 100. This gives the analytical foundation for the step in the process of reduction by which the actual values of T and Q are reduced to the standard revolutions of 100 per minute, and thus made ready for plotting.

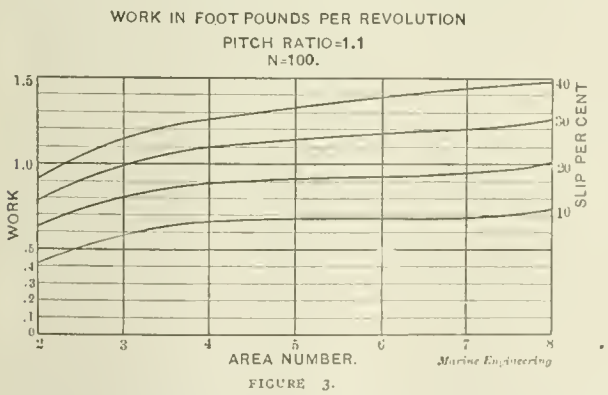


FIGURE 3.

Inversely it follows that if the values of a, b, c, x, y, z, or of their products abc and xyz as derived from a given observation, be assumed to hold for a larger propeller of similar form at the same slip, then (1) and (2) will serve to compute the thrust and torque, and hence the useful work and total work which the operation of such a propeller at revolutions N would involve. This gives the basis of the application of such results to the operation of design, a topic which will not be considered in detail in the present paper.

As a different basis for the reduction of the observed values to standard conditions we may write (1) as follows:

$$T = d^2\,[p^2N^2(1-s)^2]\,\frac{a}{(1-s)^2}bc.$$

But

$$pN(1-s) = u,$$

and we have, therefore:

$$T = d^2u^2\,\frac{abc}{(1-s)^2} \quad \ldots\ldots (9)$$

Similarly we find:

$$Q = d^2pu^2\,\frac{xyz}{(1-s)^2} \quad \ldots\ldots (10)$$

For a standard unit speed of 100 f. m. = 1 unit and with $d = 1$ we then have:

$$T = \frac{abc}{(1-s)^2} \quad \ldots\ldots (11)$$

$$Q = \frac{pxyz}{(1-s)^2} \quad \ldots\ldots (12)$$

These equations show that for fixed values of d, p, a, b, c, x, y, z (that is, for a given propeller at fixed value of the slip), T and Q will vary as u^2, and hence the actual observations which

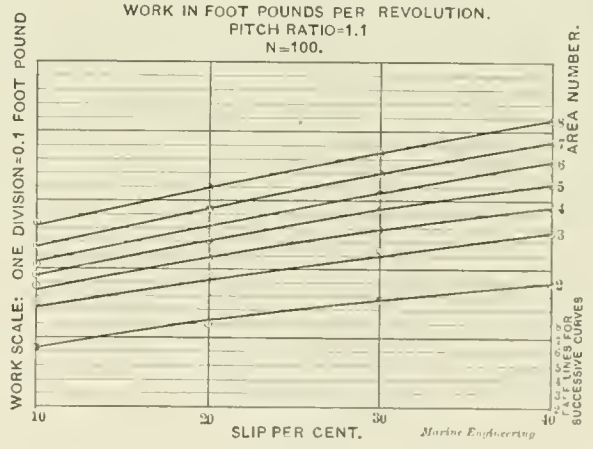


FIGURE 4.

were made at a nearly constant speed of 300 f. m. may be reduced to the standard speed by dividing by the square of the actual speed expressed in units of 100 f. m. This gives the analytical foundation for the step in the process of reduction by which the actual values of T and Q may be reduced to the standard speed of 100 f. m., and thus made ready for plotting.

Inversely it follows that if the values of $a \div (1-s)^2$, b, c and $x \div (1-s)^2$, y, z, or of their products $abc \div (1-s)^2$, $xyz \div (1-s)^2$ as derived from a given observation be assumed to hold for a larger propeller of similar form at the same slip, then (9) and (10) will serve to compute the thrust and torque, and hence the useful work and total work which the operation of such a propeller at speed u would involve.

These two methods of reduction are readily connected together by noting that the relation between (7) and (11) or (8) and (12) is expressed by the factor $p^2(1-s)^2$. That is, the values given by reduction to a standard speed of 100 f. m. as in (11) and (12) when multiplied by $p^2(1-s)^2$ will give the values reduced to standard r. p. m. of 100 as indicated by (7) and (8).

In the reduction of the observations to suitable form for

graphical representation either method might be followed; that is, the results might be reduced to a standard value of the r. p. m. or of the speed in feet per minute. Both methods are equally correct and either will express all the facts. In the actual case it is found that the values of T and Q when reduced to a standard value of the r. p. m. and plotted for a given propeller on an abscissa of slip fall nearly on straight lines, and that in groups the resulting curves are more compact and somewhat more manageable than those resulting from reduction to standard speed. For this reason the reduction to standard r. p. m. has been preferred for the general method of treatment, and especially for the graphical representations shown in the various plates,* 5-32 expressing T and Q on abscissæ of slip and area.

REDUCTION OF DATA.

For the actual reduction of the various observations the following general routine was followed:

The initial data consisted of dynamometer records giving measures of thrust and turning moment, together with strips of paper containing the records of time, distances and revolutions. The latter were readily converted into revolutions per minute and speed in feet per minute, from which, with the known pitch of the propeller, the slip could readily be found.

The actual data were all worked over by reduction to both standard speed and standard r. p. m.; but for reasons as given above, the reduction to standard r. p. m. is preferred for presentation of the results in graphical form.

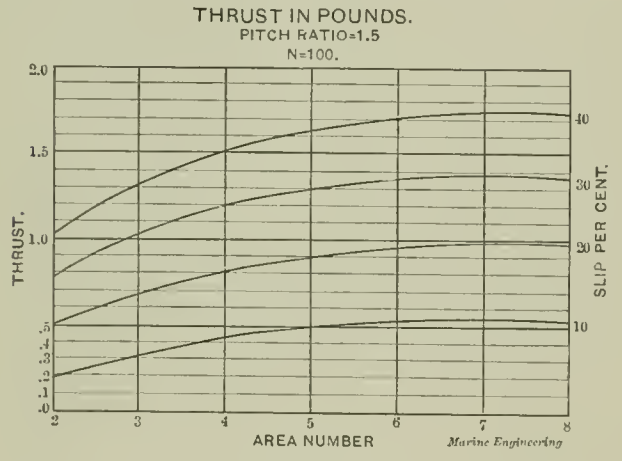


FIGURE 5.

The dynamometer records, through the usual calibrations, were readily transformed into actual forces in pounds or turning moments in foot pounds and such actual forces and moments were then reduced to their corresponding values at 100 r. p. m. by dividing by the square of the revolutions expressed in units of 100.

These results give for each propeller for both T and Q a series of values corresponding to successive values of the slip, as it may have resulted from the several settings employed, and all reduced to the standard of 100 r. p. m.

The number of such points or single observations varied somewhat with special circumstances, but was usually not less than 25 or 30 and sometimes rose to 50 or more. Such points for T and Q† were then plotted on the axis of slip and a fair curve was drawn through and among the points giving the best general graphic law between T and s or Q and s which could be derived from the observations. The resulting curves are indicated as nearly as may be, and, of course, at reduced scale, by the spots on the diagrams, such spots representing these curves at exact values of the slip 10, 20, 30 and 40 percent. Cross curves were then drawn at these values of the slip, giving the values of T and Q on an axis of increasing area. Such cross curves naturally

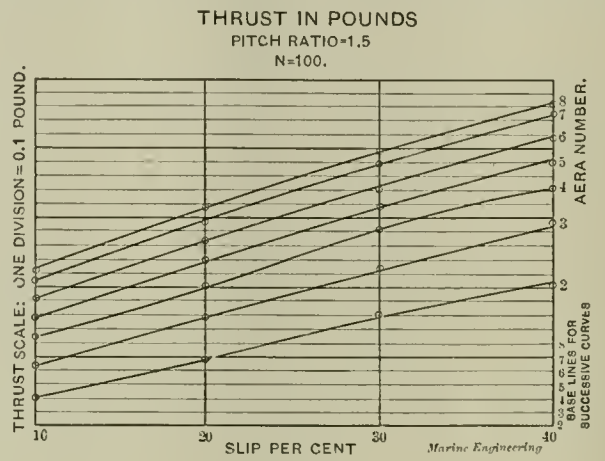


FIGURE 6.

indicated the need of some fairing up process with reference to the two sets of curves in order to derive a smooth general law for the series of seven propellers of fixed pitch and varying area. The results of such fairing up process are shown by the actual curves, one-half showing values of T and Q on slip as an abscissa and the remainder the same items with area as an abscissa.

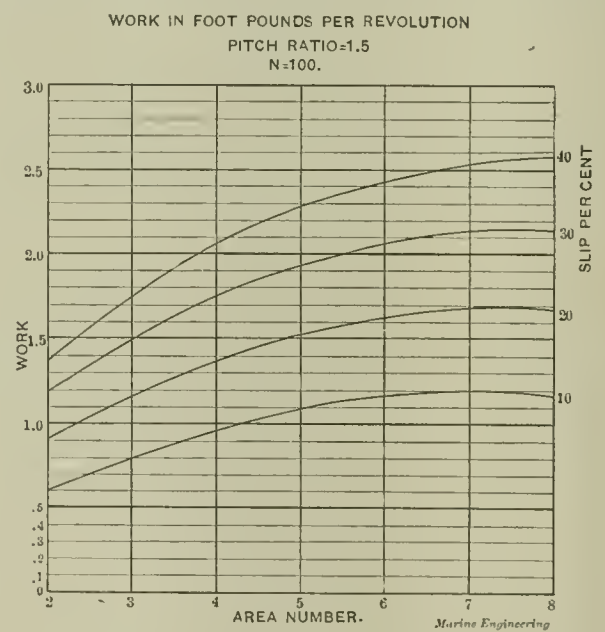


FIGURE 7.

It should be further noted that naturally the propellers as actually made were not all exactly the same diameter nor were all of exactly the rated pitch or area. All geometrical functions of the propellers as actually used were, however, carefully determined at the close of the experiments and the results tabulated. These measurements included determinations of diameter, of the area of each blade, of the pitch of each blade and average pitch, and a general map of the thickness lay out on each blade throughout the series. The variations from normal rating were in all cases quite small and for the most part might have been neglected. Appropriate corrections were, however, applied in such manner as to allow for these minor divergencies from the rated characteristics. We shall, however, consider the details of these corrections as lying beyond the scope of the present paper.

* Due to lack of space, twelve plates only have been reproduced.

† As actually plotted the values of Q are multiplied by 2π thus giving work in foot pounds per revolution.

The resulting groups of curves may, therefore, be viewed as giving the best general law connecting T and Q with slip and area, each for a given value of the pitch ratio as indicated.

EFFICIENCY TABLE.

Pitch Ratio.	Slip Ratio.	Area Numbers. 2	3	4	5	6	7	8
.9	.10	.59	.65	.65	.62	.62	.61	.60
	.20	.66	.68	.68	.69	.66	.65	.64
	.30	.66	.68	.66	.66	.64	.61	.60
	.40	62	.61	.62	.61	.60	.59	.56
1.1	.10	.63	.63	.63	.65	.65	.63	.56
	.20	.70	.70	69	.70	.70	.66	.62
	.30	.70	.68	.68	.67	.65	.62	.59
	.40	.66	.64	.63	.62	.59	.57	.56
1.3	.10	.51	.54	.55	.59	.61	.64	.65
	.20	.66	.68	.69	.68	.68	.69	.69
	.30	.68	.68	.68	.66	.66	.66	.66
	.40	.66	.65	.62	.61	.60	.60	.59
1.5	.10	.47	.56	.61	.60	.61	.61	.62
	.20	.65	.71	.69	.69	.69	.71	.71
	.30	.71	.72	.72	.69	.69	.68	.68
	.40	.68	.69	.66	.64	.63	.62	.60
1.7	.10	.50	.58	.61	.63	.63	.64	.65
	.20	.73	.73	.72	.71	.70	.70	.70
	.30	.72	.73	.72	.70	.70	.68	.68
	.40	.70	.69	.66	.64	.64	.63	.63
1.9	.10	.46	.56	.62	.63	.61	.62	.59
	.20	.67	.71	.74	.73	.71	.71	.69
	.30	.70	.73	.73	.73	.70	.69	69
	.40	.65	.67	.67	.66	.64	.63	.63
2.1	.10	.52	.58	.61	.59	.61	.61	.61
	.20	.70	.69	.68	.69	.68	.68	.70
	.30	.74	.73	.70	.69	.69	69	.69
	.40	.68	.64	.64	.63	.62	.62	.64

Values of the efficiency were then found by multiplying the values of T by $100p\ (1-s)$ and those of work per revolution by 100, and dividing the former by the latter. The results for efficiency are shown in tabular form in Table I, such mode of presentation being preferred for the present paper on account of the large number of separate diagrams needed to show the various efficiency curves which would result.

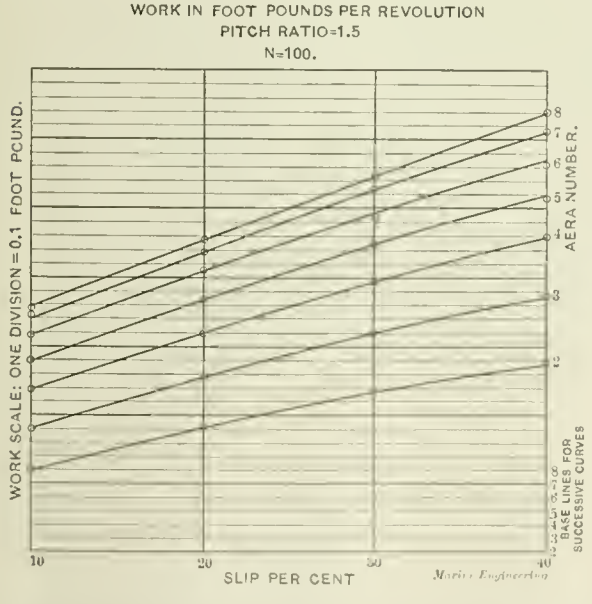


FIGURE 8.

The actual work of reduction has naturally contained a great number of special operations and devices in order to develop a comprehensive relation between the initial data and the final results in terms of thrust, work and efficiency. Into the minor details of such operations it will be unnecessary to go in the present connection, and the above brief statement will serve to show the general lines which were followed in the reduction of the results as herein given.

GENERAL RESULTS.

The curves showing values of T and Q on s, the values being reduced to standard r. p. m., are lines nearly straight or curved slightly concave to the axis of slip. This general character of the relation between Q and s or T and s is distinctively characteristic of the propeller, and has been indicated by all previous experiments carried out in detail and covering the determination of the data in such form as to bring out this relation. There is, of course, no reason for assuming that such law is naturally linear or that there is any natural reason for expecting a straight line relation between these quantities. The general trend of the curves as shown indicates clearly, however, a somewhat slower increase of T and Q with s than the exact linear law would require. It may be noted here also that further special experiments which are not included in the data given in the present paper and which show the results for 100 percent slip, indicate such values of T and Q at this extreme point as would require a marked curving over of the line, especially for values of s beyond 30 and 40 percent. From all the data at hand it can be fairly assumed that the typical relation between T and s or Q and s when T and Q are reduced to standard r. p. m. is represented by a line generally curving over concave toward the axis of s. The curvature is, furthermore, so gentle between ordinary limits of perhaps 10 and 30 percent that without serious error the law between these points may be taken as linear and, therefore, as expressible by a simple equation of the first degree.

It will be further noted that the slope of such lines increases with the area ratio and with the pitch ratio according to some complex law which is obviously a function of these two characteristics.

The relation of T to increasing area is shown. These curves show comprehensively the general relation between these two

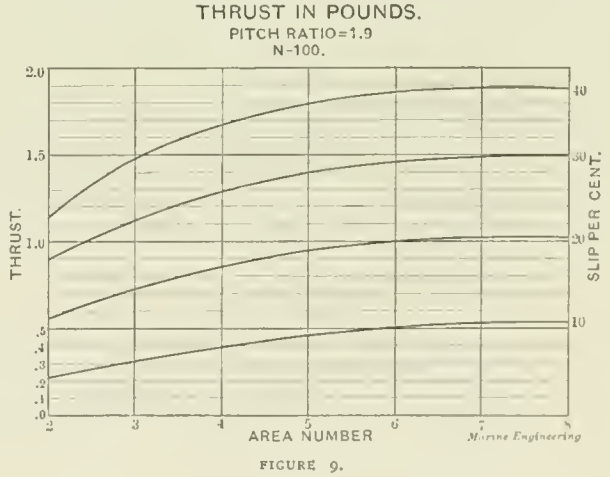


FIGURE 9.

features and indicate in particular how inconsiderable is the gain in thrust beyond area ratios of .50 or .60. Indeed, for low pitch ratios the thrust falls off slightly beyond such values of the area, showing how useless it is, especially with low pitch ratios, to increase the area beyond the usual upper limits of .50 to .60. This same general result has been indicated by other experiments, and among others by those reported by Naval Constructor Taylor at the last meeting of the Society. For the higher pitch ratios there is, as a rule, a gradual increase in thrust up to the largest employed, but the actual gain beyond area ratios of .50 or .60 is so small as to be of comparatively small importance. The general character of these curves varies but slightly with the slip, all showing the same comparatively rapid increase between area numbers 2 and 4 or 5, gradually decreasing to no increase of importance between 6 and 8.

Similarly, values of Q are shown, plotted on area ratio. These curves have all the same general character as those for T. The increase with area is, however, continuous and relatively more pronounced than for T.

These general results for T and Q plotted on area are in accord with the indications of theory on the same general points. It is clear that with a low pitch ratio in particular the effective thrust will be limited by the interference of one blade with another as the area is much increased, and by the continuous increase of the frictional or tangential component of the forces which act along the face of the blade and exert a continuously increasing longitudinal component aft, while the direct forward thrust due to the interaction of the blade and the water reaches an early limit as the blade is widened beyond limits corresponding to .40 or .50 area ratio. On the other hand the tangential component at least will grow continuously with the increase in area and this will give a small though continuous increase in Q with increase of area. With higher pitch ratios the same general relations hold, but the blades interfere less with increasing area and the limit of forward thrust due to the interaction of propeller and water is less quickly reached, while at the same time the value of Q increases continuously with area, though slowly beyond a limit of .50 area ratio.

The efficiency relations shown in the table are of high interest and the general laws indicated will repay careful attention. The general character of the variation of efficiency with slip for a given propeller is well known and is indicated by the figures of the table. The values are low for low slip, rising rapidly to the maximum in the neighborhood of 20 to 30 percent and then falling more gradually as the slip increases beyond such value.

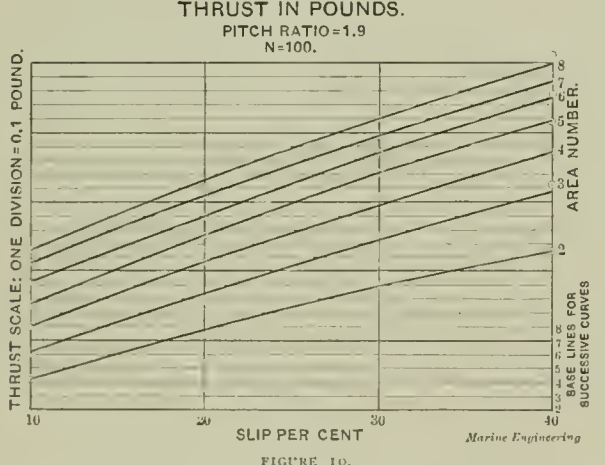


FIGURE 10.

In general there is indication that the propeller of very small area reaches its best efficiency at a relatively high slip, usually in the neighborhood of 30 percent, while that of large area reaches its best value at about 20 percent or below. The highest values seem, furthermore, to be only slightly dependent on either area or pitch ratio. The low pitch ratio with high area, as would be expected, shows the lowest values of the efficiency. Outside this territory all the propellers reach at some value of the slip a value of the efficiency closely approximate to 70, the best general results being indicated for fairly high pitch ratios and moderate areas.

Stated otherwise, these general efficiency relations indicate for a low slip, such as 10 percent, a general increase of efficiency with area, except for the lowest pitch ratios, when such increase is followed by a decrease for the highest areas. For higher values of the pitch ratio and low slip, however, there is as a rule, first a marked and then a slow increase of efficiency with increase in area, the best results being given for area ratios of 35 to 45. On the other hand, for high values of the slip, such as 40 percent, there is, as a rule, a continuous though perhaps slow decrease of efficiency with increase of area from number 2 to 8, or throughout the range. Intermediate between these extremes we find for moderate or average values of the slip between 20 and 30 percent but slight change of the efficiency with

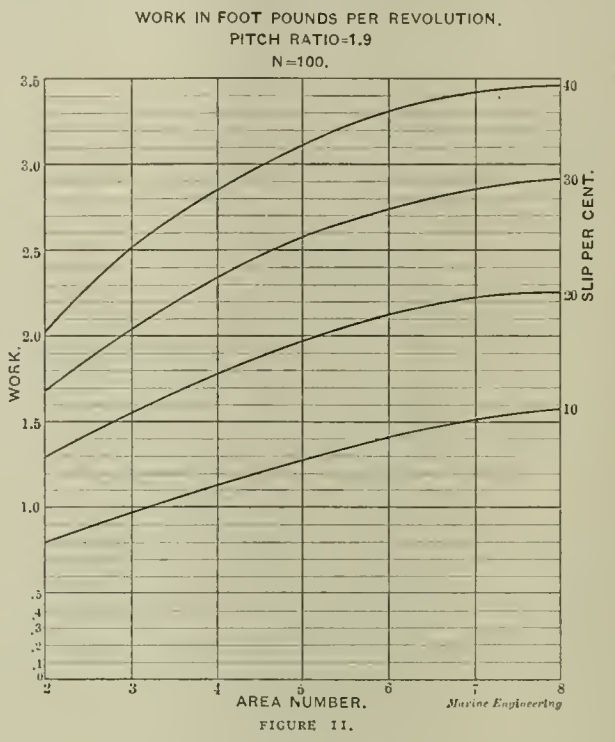


FIGURE 11.

area. For the lowest pitch ratio, however, the decrease of the efficiency with area for these intermediate values of the slip is still well marked. It appears, therefore, that if values of the pitch ratio below 1 are employed, the propeller should be so

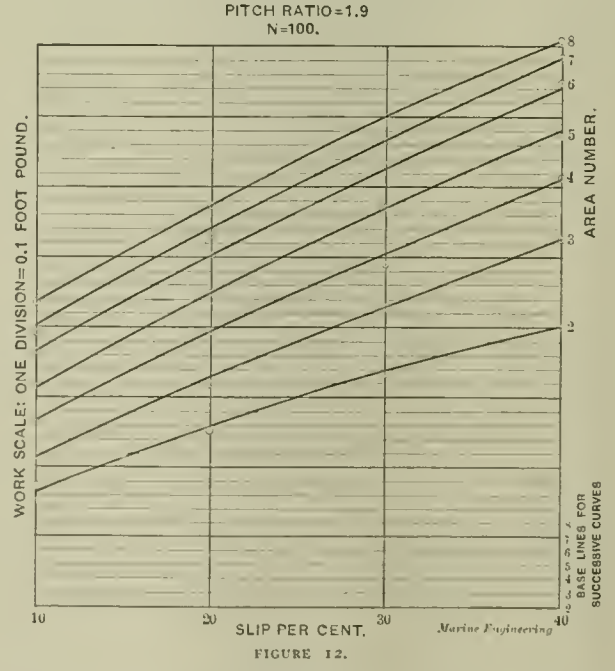


FIGURE 12.

proportioned as to work with a small area and high slip. On the other hand, for propellers lying within the more common ranges of pitch ratio and area, and operating at values of the slip between 20 and 30 percent, it appears that the efficiency will vary but slightly over the entire mid-field range thus indicated, and that any proportions corresponding to operation within these general limits may be freely chosen without fear of any

important drop in the efficiency below the upper limits of 68 to 70 percent.

The application of these results to the problems of design involves the deduction of a series of factors or "constants" relating them in a convenient manner to the indicated horsepower and speed. This operation presents nothing unusual or novel and will not be included in the scope of the present paper, the purpose of which is purposely confined to an actual report of the data taken expressed directly in terms of thrust and foot pounds work per revolution as related to slip and area ratio.

The deduction of such constants as may serve to aid in the operation of design will find a place in the more complete report which will be later published under the auspices of the Carnegie Institution.

THE CRUISER NATAL, ENTERING THE WATER.

The New English Cruiser Natal.

The first warship that the Colony of Natal agreed to make as contribution in the maintenance of the first line of defense has been recently launched. The main dimensions of this vessel, to which the name of *Natal* has been given, are as follows: Length between perpendiculars, 480 feet; breadth extreme, 73 feet 6 inches; displacement at 27 feet draught, 13,550 tons. The normal coal supply carried is to be 1,000 tons, but bunker capacity has been provided for a much increased supply.

The cylinders of the propelling machinery are supported on an "A" frame at the rear, with forged steel columns in front, and are arranged on the Yarrow-Schlick-Tweedy system of balancing, being placed in couples close together, with the valves to the outside. The cylinders, four in number, are arranged for triple compounding. The diameter of the high-pressure cylinder is 43½ inches; intermediate, 69 inches, and of each low pressure 77 inches. Slide valves are used for the two low-pressure cylinders, and piston valves for both high and intermediate cylinders. The stroke is 42 inches, and with the machinery running at 135 revolutions, a total of 23,500 indicated horsepower is expected to be realized. The two propellers are of manganese bronze, with adjustable blades, and work outward when the vessel is going ahead. The main condensers, of gun metal, are oval in section, with brass tubes, there being two to each set of engines, making four in all, each with its own centrifugal pump of gun-metal, with independent engine. The air-pumps are entirely separate.

The *Natal* is fitted with twenty Yarrow boilers and six cylindrical boilers, two-thirds of the power being represented by the former. The proportion of power to weight of machinery is about 10½ horsepower per ton. The speed anticipated is 22.5 knots, and the complement of officers and men is about 700.

The *Natal* mounts six 9.2-inch and four 7.5-inch guns, and her equipment for dealing with torpedo or submarine attack includes 23 quick-firing guns, two 12-pounders and two Maxim guns.

The *Natal* belongs to the first cruiser class in England in which the 6-inch guns have been entirely dispensed with, and although this has involved a reduction in the number of guns, the gain is enormous in the penetrating power of each shot fired. In fact, the 6 inch gun at its best has a muzzle energy of 6,000 foot-tons, while the 7.5-inch gun, 50 calibers in length, develops a muzzle

energy of over 11,500 foot-tons. The 9.2-inch guns, 50 calibers, develop a muzzle energy of 24,000 foot-tons. Assuming, therefore, favorable conditions, so far as rapidity of firing is concerned, the *Natal* will develop 835,000 foot-tons of muzzle energy for each minute of fire, as compared with 829,000 foot-tons in the preceding cruisers. She may fire per minute 48 shots, which can be effective at three miles range.

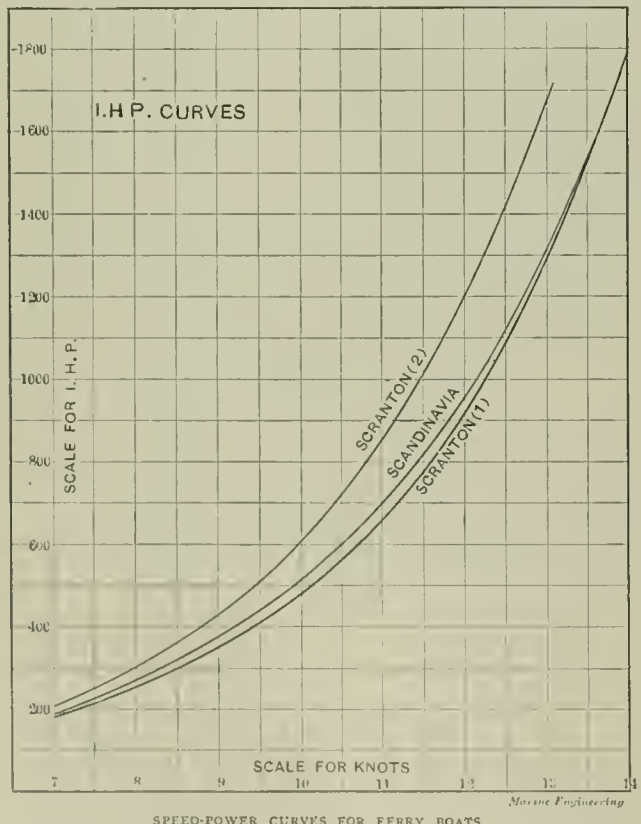
Another important improvement in connection with the armament of the ship is the great height of the gun platform above the sea level. The 7.5-inch pieces are placed within casemates on the upper deck, one on each side, near the center of the length, the protecting armor being 6 inches in thickness. In turrets forward and aft are located two 9.2-inch guns, encased in barbettes of 6-inch armor, decreasing to 3 inches at the base. On the four quarters of the citadel there are similar 9.2-inch weapons, close to the broadside, and as the forecastle structure is cut away, these guns fire in line with the keel, and have an arc of fire of 180 degrees. The side armor is 6 inches thick. This thickness is thinned down by two stages, first to 4 inches, and at the ends to 3 inches.

It has been said that the *Natal* is perhaps the last armored cruiser type to be built for the English navy, more powerful ships being now called for. E. O.

SOME PROBLEMS IN FERRYBOAT PROPULSION.*

BY COL. E. A. STEVENS.

The propulsion of double-ended screw boats offers some difficult problems in screw design. The subdivision of the power shown by the indicator is very complex, and its exact distribution is, with the knowledge at hand, well nigh impossible. There are also few instances in which screw design is of more importance.



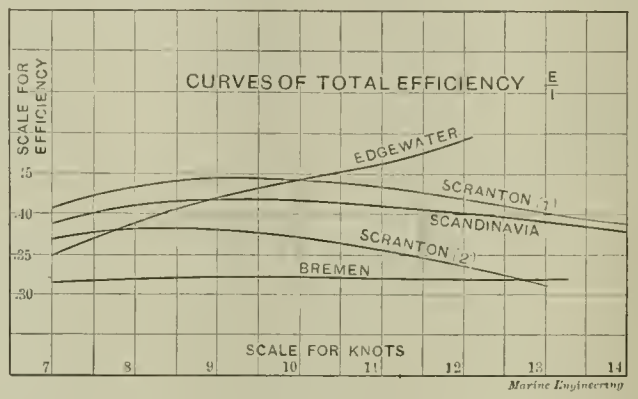
SPEED-POWER CURVES FOR FERRY BOATS.

The *Scranton* class of boats recently put into service on the Hoboken ferries can serve as an illustration. The wheel originally designed for these boats did not give satisfactory results in backing. It was decided to try a wheel of another type. The main dimensions were as follows:

*Read at the thirteenth general meeting of the Society of Naval Architects and Marine Engineers, November 16, 1905.

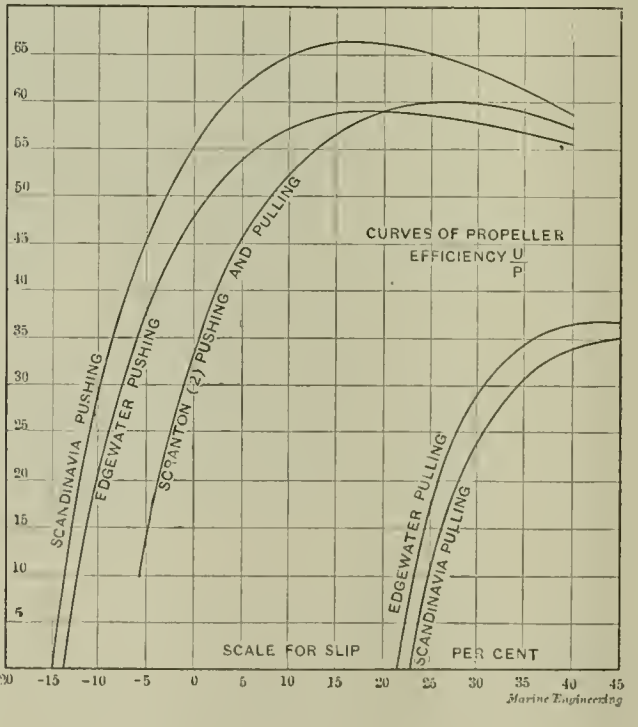
	Wheel No. 1.	*Wheel No. 2.*
Diameter	10′ 0″	9′ 3″
Pitch	11′ 1½″	10′ 6″
Developed area	38.8 sq. ft.	38.5 sq. ft.

The first wheel had blades of oval outline with rounded backs and a directrix curving to the rear. The second wheel was of the so-called DeLamater type, with sections designed to give



TOTAL PROPULSIVE EFFICIENCY.

equal efficiencies in both motions and with vertical directrix. With greatly reduced slip the second wheel consumed about 20 percent more power at the designed speed without any appreciable gain in backing power. On the subsequent boats the original wheel was cut down in diameter and area. The power curves show the results obtained by the *Scranton* with both wheels, and by the *Scandinavia*, a sister ship, with a smaller wheel of the same type.



PROPELLER EFFICIENCIES, FORWARD AND REARWARD.

In discussing these results I adopt the following symbols:

I = indicated horsepower.
F = horsepower consumed in engine friction.
Pl_s = horsepower consumed in stern propeller losses.
Pl_b = horsepower consumed in bow propeller losses.
$Td\text{-}Wg$ = horsepower consumed by difference between thrust deduction and wake gain.

E_r = horsepower consumed by action of race of forward screw.

E = tow line horsepower.

$P = I - F = P_s$ (power delivered to after wheel) + P_b (power delivered to bow wheel).

Now $I = F + Pl_s + Pl_b + Td\text{-}Wg + E_r + E$.

T can be very closely approximated from tank trials.

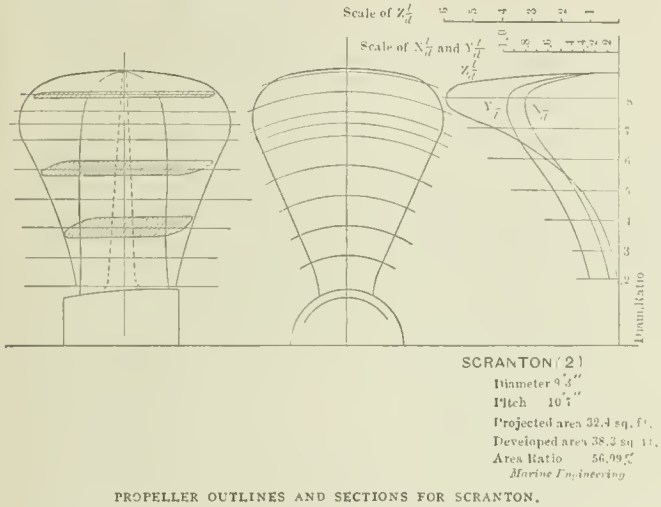
F can be estimated with some approach to accuracy.

$Td\text{-}Wg$ in these boats is probably negligible in design.

Whence $P - E = Pl_s + Pl_b + E_r$.

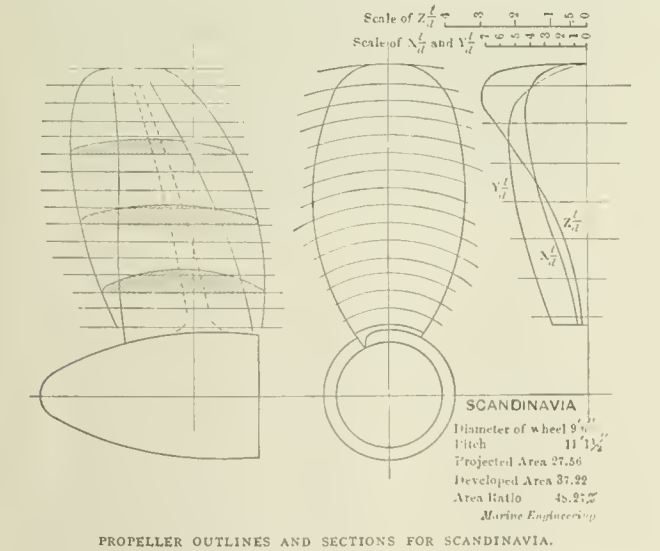
This latter quantity is the one that it is specially desirable to determine.

With a view of so doing, I had model wheels of *Scranton* (2), *Scandinavia*, and *Edgewater* (see Transactions N. A. and M. E., 1902), tested in the United States experimental basin. The resulting curves give the efficiencies and power-absorbing factors for the wheels at various slips.



PROPELLER OUTLINES AND SECTIONS FOR SCRANTON.

Taylor's formula, in which these factors are to be used, is given in the Transactions of 1904. It is, P = constant $\times Sd^2v^3$, in which S is the factor. This formula gives, in this case, much more power than was found on trial. The difference in material and surface, and the fact that the model was accurately finished to pitch, would account for some of the excess power given by



PROPELLER OUTLINES AND SECTIONS FOR SCANDINAVIA.

the model screws. After making reasonable allowance for these differences, some other factor will probably have to be introduced in applying model results to actual practice. This conclusion, I understand, is also shared by Naval Constructor Taylor. In view of this uncertainty, it does not seem advisable to publish these power factors at this time. As before said, we know the values of P and E in this case, but in order to know the values of Pl_s and Pl_b, we must be able to subdivide P into P_s and P_b. To do this from experimental tank data, the wake, and hence true slips, of both screws must be known.

The race from forward screw undoubtedly seriously affects the wake at stern; there is no experimental data as to the wake of the forward screw. With the further uncertainty as to the power absorbed by each screw, it is very doubtful whether any set of assumptions would yield satisfactory results in analysis. The most probable assumptions indicate that the results will not vary much from those given in the analysis of the *Bremen's* trial (see Transactions N. A. and M. E., 1903) in the case of wheels of similar design, such as were used on *Scranton* (2). Such assumptions also lead to a power subdivision and analysis that give explanations of the actual results, as shown by the two trials of the *Scranton;* but they are not so exhaustive as to warrant publication. I submit, however, plates showing curves of total efficiency of propulsion; propeller efficiencies in both motions; and developed outlines, sections, etc., of propeller blades.

As to these curves, I would draw attention to the remarkable difference in total efficiency curve in the case of the *Edgewater* and the other boats. The propeller efficiencies are about what one would expect for wheels of fine pitch, large area ratio, and coarse blade section. They approximate closely to the values given by Taylor's formula,

$$e = (1 - s)\,\frac{asX_c - fY_c}{asX_c + fZ_c},$$

if a be taken at from 4 to 6. I am convinced that the efficiencies are, practically, correct in these cases. The efficiencies in backing are affected by the blade section and form of generatrix.

It should be remembered that the *Edgewater's* sections are coarser than *Scandinavia's*. In view of the uncertainty as to true slips, it may not be out of place to call attention to the fact that the substitution of wheels of the type used on *Scandinavia* may, while reducing power at a given speed, actually increase the maximum strains, both in torsion and thrust on the shafting.

A WOODEN PASSENGER STEAMER FOR ONEIDA LAKE.

From the designs of Mr. Henry J. Gielow, of New York, a new passenger steamer has just been built for the Bay Road Construction Company for use on Oneida Lake. The dimensions include a length of 98 feet overall and 88 feet 9 inches on the waterline, an extreme beam over guards of 22 feet 3 inches, a 7-foot depth of hold and a draft of 5 feet 6 inches. The keel is of white oak 10 by 8 inches, the stem of white oak 8 inches thick and of suitable shapes for maintaining the form desired, with deadwood forward of the same material and thickness. The stern post is also white oak, sided 10 inches at keel and cross seam and 16 inches at center of shaft, and molded 12 inches; the aft deadwood, 10 inches thick, is of yellow pine, with a stuffing box log of the same material 16 inches square. The rudder post is of wrought iron 1¼ by 5 inches, with T-shaped head and feet, and a shoe of wrought iron 1½ by 6 inches extending 6 inches forward of after side of stern post, with two pairs of jaws. The rudder stock is of wrought iron 3½ inches in diameter, tapering to 2¼ inches at the keel, and the rudder frame has a thickness tapering from 2½ inches at the stern post to 1½ inches at the after side. This frame is covered with ⅜-inch wrought iron, the open spaces being filled with white pine.

The frames are of white oak, hackmatack and chestnut, spaced 26 inches centers, sided 4 inches and molded 8 inches at keel, 6 inches at turn of bilge and 5 inches at plank sheer. The floors are natural crooks with alternate long and short arms, with 1½ by 2½-inch limber holes on each side of the keel. Under the engine and boiler spaces is a solid filling of yellow pine. The keelson is of pitch pine 10 inches by 10 inches. The garboard

strake is 3 by 10 inches; sheer strake 2½ inches by 9 inches; three wales 2½ by 6 inches, all of white oak. The balance of the planking is of yellow pine 2½ inches in thickness. Wearing pieces are fitted of white oak 6 by 6 inches, with rounded corners, with a pair of fenders extending 12 feet aft from stem. The ceiling is of yellow pine 2 inches thick from clamps to bilge strakes and 1½ inches below that. The bilge keelsons are of yellow pine 6 by 8 inches; beams of the same material molded 10 inches at centers and 5 inches at ends and worked with a crown of 5 inches amidships; siding 4 inches and 6 inches respectively.

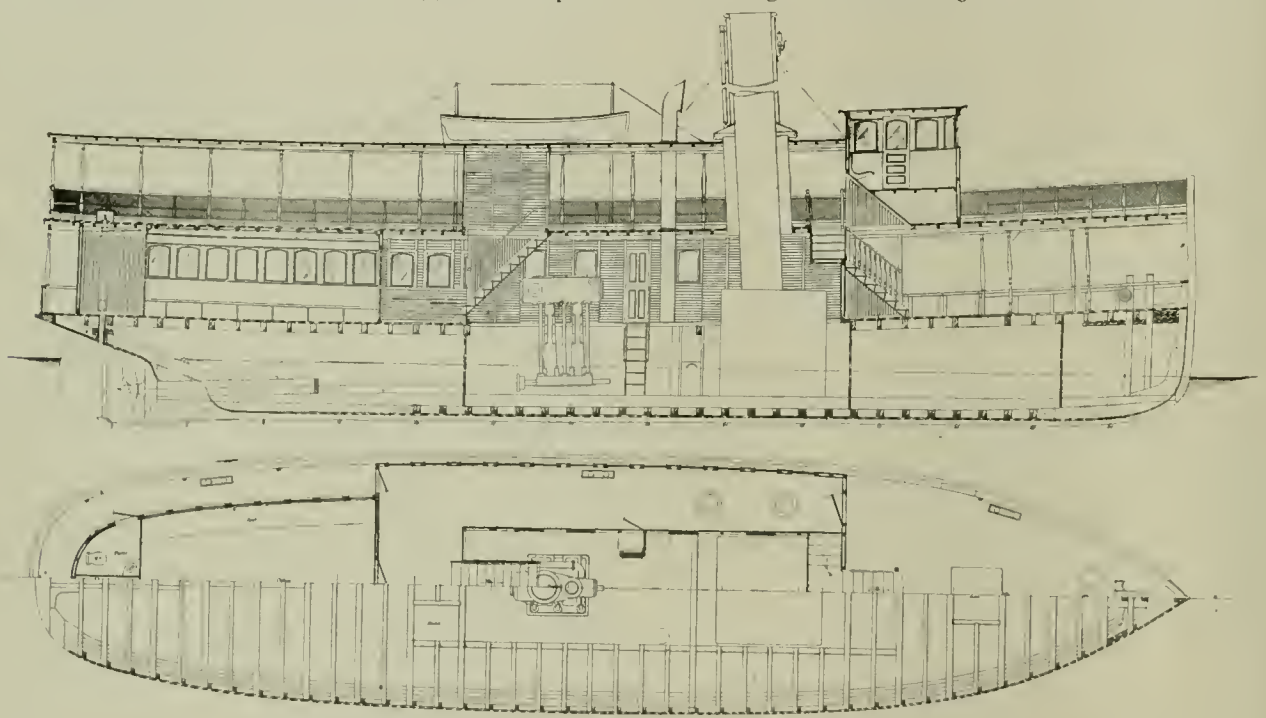
The plank sheer is of white oak 2 inches thick and 12 inches wide, let down over the stanchions; the deck planks are dry, white pine 2 inches by 3 inches; the rail is of white oak 2¼ by 6 inches with top rounded off; rail 1⅛ by 4½ inches; bulwarks are of white pine 3 by ⅞ inches.

There are three bulkheads, located respectively at frames 16, 31 and 39, being of yellow pine 2 inches thick and stiffened by intermediate stanchions 3 by 4 inches. Coal bunkers are located on each side of the boiler, and constructed of ¼-inch steel plates stiffened with 2 by 2½ by ¼-inch vertical angle bars spaced 21 inches. Coamings for engine and boiler hatches are of yellow pine 5 by 6 inches.

The main deck house has a length of 65 feet 6 inches, the sides forward for a distance of 39 feet 9 inches running along the inside of the rail, while the after end allows a clear passageway inside the rail of 2 feet 6 inches on each side. The head room under the carlines is 7 feet 4 inches. The studs are of spruce 4 by 3 inches, the clamp of yellow pine 2 by 5 inches extending the full length of the hull, carlines of the same material 2¼ by 3¾ inches, 21 inches apart and extending from side to side in one length. The deck extends the full length and width of the vessel, and is of white pine 1 by 3½ inches, covered with No. 5 cotton duck and heavily painted. The outside sheathing is of white pine 1 by 3½ inches, and ceiling of the same material ⅞ by 3½ inches laid horizontally.

The center deck house, inclosing the engine and boiler spaces, is 32 feet long, 10 feet wide, with plates 3 by 5 inches, sills 5 by 6 inches, studs 2 by 3 inches and corner posts 4 by 4 inches, rabbeted to receive sheathing, which is of white pine ⅞ by 3 inches. The pilot house is on top of main deck house, 9 feet 8 inches long and 10 feet wide, with forward angles rounded and front rounded to a radius of 9 feet 8 inches; with clear head room of 6 feet 6 inches. Carlines are 1⅞ by 2⅞ inches and deck ¾ by 3 inches, covered with cotton duck. Sills are of white pine 5 by 5 inches rabbeted for receiving sheathing, which is of white pine 1 inch thick outside and ⅞-inch in ceiling; studs are 2 by 3 inches of spruce. The steering wheel has a diameter of 6 feet over spokes, and is made of locust and mahogany, with suitable equipment of chocks, blocks, sheaves, chains, etc., for serving its purpose. A spirit compass with binnacle and lamps is fitted on a shelf forward of the wheel.

From the after end of pilot house to the stern of the vessel, a distance of 71 feet, and extending the full width of the saloon deck, is a space known as the awning deck, with head room 6 feet 10 inches at center and 6 feet 8 inches at sides. The deck is ¾ by 3 inches of white pine, covered with No. 6 cotton duck. The outboard ends of carlines are supported by twenty-five turned spruce stanchions 2 inches in diameter, and eight galvanized wrought iron stanchions of the same diameter. Outside these awning stanchions and 3 feet above the deck is a white pine rail 2 inches square and supported by intermediate turned spruce stanchions 1¾ inches in diameter.

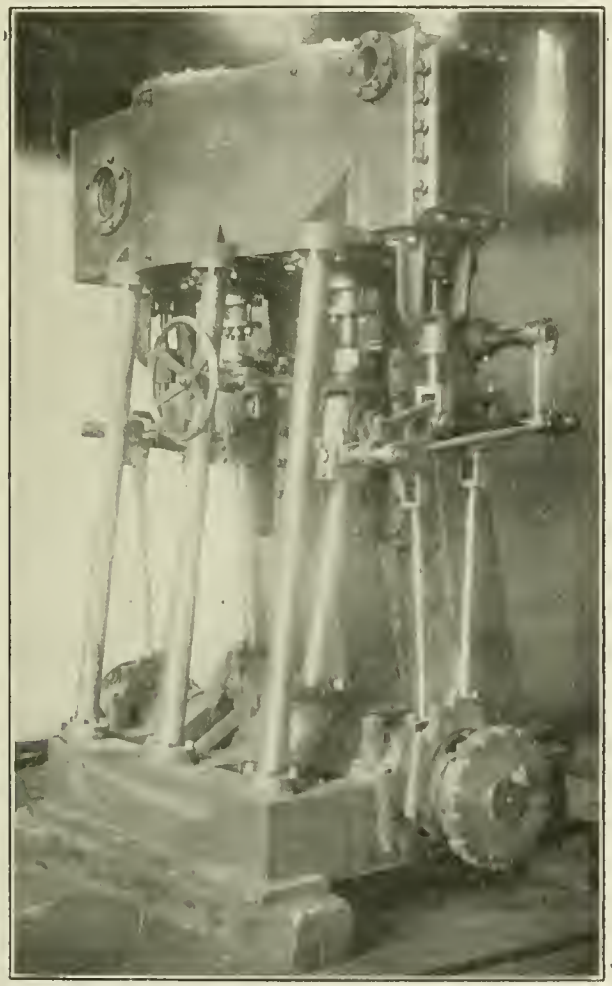


INBOARD PROFILE, HALF DECK PLAN AND HALF HOLD PLAN OF ONEIDA LAKE STEAMER.

There is an inverted surface condensing compound engine, built by the Morris Machine Works, Baldwinsville, N. Y., with two cylinders and cranks at an angle of 90 degrees, operating a single screw. The high-pressure cylinder has a diameter of 14 inches and low-pressure 28 inches, both with 18-inch stroke. The steam ports of high-pressure cylinder measure 13⅜ and exhaust ports 31⅝ square inches. The low-pressure cylinder has steam ports measuring 38½ and exhaust port area 60½ square inches. The cylinder barrels have a thickness of 1⅛ inches, with counterbore of 3/32 inch in each end. Both cylinders and steam chests are to be lagged with felt and Russia iron. The steam chests are cast in one piece with the cylinders, and a relief valve is fitted on each. The slide valves are of the ordinary D form, of cast iron. The bedplate of the engine is one casting, composed of two fore-and-aft and three transverse box girders, the framing consisting at the back of the engine of two cast iron box columns measuring outside 12½ by 13 inches at the bottom and 8 by 9 inches at top, with shell one inch thick, and with crosshead guides 7 inches wide cast on inside faces.

The front columns are wrought iron, 3½ inches in diameter, finished, and fitted with suitable flanges for fastening to cylinders and bedplates.

The pistons are of cast iron double shell, with cast iron followers and packing rings. The piston rods are of mild steel, 2⅝ inches in diameter, screwed into pistons and crossheads. The latter are of cast steel with journal 4 inches diameter and 5 inches long. The crosshead slippers have a wearing surface of 84 square inches. The connecting rods are of hammered iron 3 feet 10 inches long between centers and measuring 2¾ inches in diameter of neck at crosshead end, and 2¾ by 4 inches at crank end. The crank shaft is of forged steel in one piece with crank arms 4½ inches thick and 7¾ inches wide. Crank



THE COMPOUND ENGINE.

pin journals are 6½ inches long and 6¼ inches in diameter, and the line shafting is fitted in two lengths, of forged steel, 6 inches in diameter with cast steel disk coupling. The bearing surfaces on thrust bearing receive a maximum pressure of not more than 40 pounds per square inch. Besides the thrust bearing there are three main bearings 6¼ inches in diameter, and respectively 8, 11¾ and 8 inches long. All are fitted with removable babbitt-lined shells. The valves are operated by the Stephenson link motion, of the single bar pattern, with a throw of about 12 inches. Each link is operated from two eccentrics with 1¾-inch face. The links and valve motion are made of steel, with take-up on all connections. The valve stems are 1⅞ inches in diameter.

The air pump and jet condenser is of a horizontal double-acting type, with steam and air cylinders respectively 8 and 14 inches in diameter and 12-inch stroke. The condenser is of the cone type, fitted with composition spray valve. The feed pump and injector are of the horizontal duplex type, with steam and water cylinders 5¼ and 3½ inches in diameter with a 5-inch stroke, and with water end designed for a working pressure of 200 pounds per square inch and a temperature of 150 degrees. A bilge ejector with a discharge nozzle 2 inches in diameter is fitted. The main and exhaust steam pipes are of pressed copper, 4½ inches and 8 inches in diameter respectively. The electric light plant consists of a direct-coupled generating set with an output of 7 kilowatts at 550 revolutions per minute. The engine is vertical, 5 by 4½ inches, and fitted with an automatic governor; the voltage is 110. There are a searchlight 13 inches in diameter and 60 incandescent lights.

The propeller, which has four blades, is of cast iron, 5 feet 3 inches in diameter and with a pitch of 8 feet 6 inches, giving a pitch ratio of 1.62; the projected area of the four blades aggregates 1,620 square inches. The stern bearing is 15 inches in length, fitted with lignum vitæ staves, and with a flange against the aft side of stern post. The inboard stuffing box is of cast iron with a shaft bearing of 12 inches: the usual gland is fitted to the shaft and holds the packing in place.

Steam is supplied by a safety water-tube boiler 9 feet long, 9 feet wide, 6 feet 5 inches high and tested to 500 pounds hydrostatic and 250 pounds steam pressure. It has a grate surface of 57.6 square feet and a heating surface of 1,328 square feet, giving a ratio of 23.1 to 1. The steam drum is of mild Siemens-Martin steel of a tensile strength of 60,000 pounds per square inch, and of such ductility as to give a reduction of area of 50 percent. The grate bars are single, with cast iron bearers. The furnace has two fire doors. The boiler is jacketed and lagged with magnesia. The boiler keelson consists of 2 I beams 10 feet long, 6 inches high, with a web ¼ inch thick. The single funnel is constructed of No. 12 B. W. G. steel with an inside diameter of 42 inches and a length of 30 feet. The outside stack is of No. 14 B. W. G. steel 50 inches in diameter.

Stranding of the Steamer Alicia.

Our photograph, which was sent us by Chief Engineer George H. Waring, Jr., of the steamship *Captain A. F. Lucas*, shows the position of the Spanish steamer *Alicia*, when ashore in May, on Ajax Reef, near the Fowey Rocks Lightship, Florida. The steamer was eventually taken off, after having been on the

THE ALICIA AGROUND OFF THE FLORIDA COAST.

reef about a month. The *Alicia* is described as an iron screw vessel with a length of 345 feet 2 inches, a beam of 37 feet 4 inches, and a depth of 25 feet 9 inches. She is divided by five bulkheads into six watertight compartments, and has a registered tonnage of 1,768 net and 2,705 gross. She is propelled by one compound engine with cylinders 38 and 71 inches respectively in diameter and a 48-inch stroke, and was launched at Glasgow in October, 1883.

MOTOR BOATS, VIII.

BY DR. WILLIAM F. DURAND.

THE DESIGN OF FORM.

The design of a motor boat as a whole is readily seen to divide itself into the two main problems of the design of form and the design of structure. In the present chapter we shall consider the design of form. In the preceding chapter we have discussed the principal characteristics of form and their relations with the various qualities of the boat, such as speed, safety, carrying capacity, etc. We have now to consider methods for determining in a regular and systematic manner such general form characteristics as may be desired, and for the representation of such form in manner best suited to the needs of the practical builder.

Before taking up the discussion of actual designing methods, however, brief reference must be made to certain so-called form or fineness coefficients.

Let the length of the boat on the water line be denoted by L, the breadth by B and the draft by H. Then the product B × H will be the area of a rectangle which will just contain the immersed midship section. Let M be the area of the actual section.

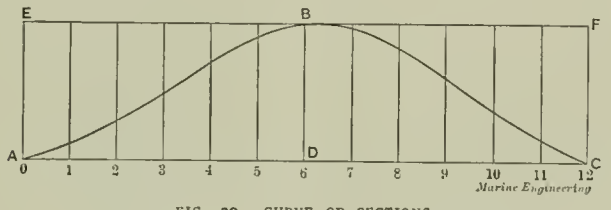


FIG. 39. CURVE OF SECTIONS.

Then the ratio M ÷ BH is called the *midship section coefficient* and represents the fraction of the total area which the actual section contains.

Likewise the product L × B will be the area of a rectangle which would just contain the water plane or horizontal section at the water line. Let A be the area of the actual water plane. Then the ratio A ÷ L B is called the *water plane coefficient* and represents the fraction of the total rectangle which the actual water plane contains.

Again the product L × B × H will be the volume of a box which would just contain the under water form. Let V be the actual volume of the under water body. Then the ratio V ÷ L B H is called the *block coefficient*, and evidently represents the fraction of the total box volume which the actual boat form contains.

Again the product L × M will be the volume of a solid of section constant and equal to M, and of length equal to that of the boat. Then the ratio V ÷ L M is called the *prismatic coefficient*, and represents the fraction of this total volume which the actual boat form contains.

It is readily seen that the indications of the midship section coefficient refer solely to the form of this section, and give an estimate of its fullness compared with a rectangle as the standard. The indications of the water plane coefficient, similarly, refer solely to the form of the load water line, and give an estimate of its fullness compared with a rectangle as the standard. The indications of the block coefficient, on the other hand, refer to volume, and give an estimate of the fullness of underwater body compared with a rectangular block or prism as the standard. Similarly the indications of the prismatic coefficient refer to volume and give an estimate of the fullness of underwater body compared with a body having length L and a constant cross section M. A little thought will also show that this coefficient refers solely to what may be termed fore and aft fining.

Suppose again the areas of a series of sections taken to the load water line, and let them be denoted by M_0, M_1, M_2, etc. Let these be plotted on an axis of length each at its own station. The result will be a curve similar to that of Fig. 39, and called a curve of sections. The maximum height of the curve, *B D*, represents, of course, the area of the midship section, or M, as noted above. The distance *A C* represents likewise the length L. Then the product L M is represented by the area of the rectangle *I C F E*. The area of the curve *A B C D A* in a similar manner represents the volume of the actual boat form, which we have denoted by V.

The complete proof of this last statement would require an application of the integral calculus, which would take us outside our purpose in the present series of articles. The fact may be seen in a semi-mathematical manner as follows:

It is clear that the volume of the boat will be measured by the length multiplied by the mean or average cross sectional area. It is likewise clear that the area *A B C D A* will be measured by the length *A C* multiplied by the average vertical dimension or ordinate. But the length *A C* represents the length of the boat, and the ordinates of the curve represent the cross sectional areas. Hence the product of the length *A C* by the average ordinate will be proportional to the product of the length of the boat by the average area of section. Hence the area of the curve will be proportional to the volume of the boat, V. It is then clear that the ratio V ÷ L M will be the same as the ratio between the two areas *A B C D A* ÷ *A C F E*. It follows that the prismatic coefficient is the area coefficient of the curve of sections, *A B C*, and shows the fullness of the area *A B C D A* compared with the rectangle *A C F E* as standard.

The usual range of value in the midship section coefficient is from .65 or .70 in the peg-top form of section as in Fig. 40, to .90 or above in the flat floor and sharp bilge form as in Fig. 41.

The usual range of values in the water plane coefficient is from .65 or .70 in very fine forms of the old or ship type with deadwood, through .75 or .80 for fine forms with torpedo boat or flat stern, and to .85 and upward for very full forms.

The usual range of value in the block coefficient is from about .40 or .45 for fine forms to .50 or .60 for moderate and to .70 for full forms. Extreme forms for high speed may have a coefficient as low as .35, and the whole range of boats for pleasure and high to moderate speed may be expected to show values of the block coefficient from this figure up to about .50.

The usual range of value in the prismatic coefficient is from about .6 for very fine high speed forms to .70 or .75 for moderate speeds, and to .80 or .85 for low speed and large carrying capacity.

We may turn now to the various plans and lines by means of which the form of a boat may be represented on the drawing board.

If we suppose a series of planes passed parallel to the surface of the water they will cut out from the form of the boat a series of lines known as water lines and having the general form shown in Fig. 36 (lower plan). Since the two sides of the boat are the same it is customary to show the lines for only one side. Hence the plan showing such lines is known as the *half breadth plan*.

If, again, we suppose the form cut by a series of planes vertical and transverse, or perpendicular to the base line, they will cut from the surface of the boat a series of lines known as *sections* and having the general form shown in Figs. 36, 34 (small plan). Here also, since it is unnecessary to show more than one side of the boat, it is customary to show on one side the sections of the fore body and on the other that of the after body. Such a plan is known as a *body plan*.

The plan shown in Fig. 36 (upper plan), and which gives the side elevation of the form, is known as the *sheer plan*. If the boat is cut by a series of fore and aft vertical planes, the lines cut out from the surface are shown in such a plan, and are called *bow and buttock lines*. Referring again to Fig. 34, if

the form of the boat is cut by a series of oblique planes running fore and aft and lying as nearly as possible perpendicular to the surface at various depths, they will cut from the surface a series of lines which may be shown, each in its own plane. Such planes, indicated by *A, B, C, D, E,* Fig. 34, are known as diagonals, and the resulting lines are shown in developed or true form in the upper plan on the right. The chief use of such lines is in fairing up the other plans so as to insure a smooth and continuous form, especially near the bow and stern, where the indications of the other plans are sometimes less definite or exact.

Referring now to Figs. 36 and 34, the water lines may be fined away sharply fore and aft, beginning from the midship section; or they may carry nearly the full width for some little distance fore and aft and then fall away more abruptly to the pointed extremities. Such forms of water line are more specially typical of the ship form with deadwood. On the other hand, with the torpedo boat stern the typical form of water plane is shown in Fig. 36. It is sharp pointed at the bow, and gradually widens, gaining its greatest width frequently at some little distance aft of the mid length, and then rounding off to the stern as shown.

With the ship form of under water body the fineness of water plane will increase as the required speed is higher, while as speed requirements are less exacting and more carrying capacity is required, the water lines will become fuller in form, and the bow and stern will become less sharply pointed. With very full boats of this form the after body should preferably be somewhat finer than the fore body, in order to diminish eddy resistance at the stern and facilitate the flow of water to the

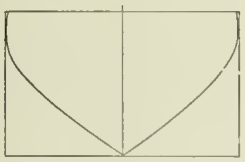


FIG. 40.

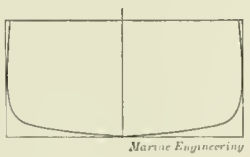


FIG. 41.

propeller. With the torpedo boat type of stern the form of the water lines in the after body shows but slight variation, with general fullness of form. With the fore body, however, the general fineness of water line is greater, and the angle of entrance is less as speed requirements are greater.

Turning now to the body plan, the sections may at one extreme be nearly rectangular, or at the other extreme more nearly triangular, or even hollowed in as near the stern in ship-formed bodies. The general character of the transverse sections in any one boat is to a considerable extent determined by the form of the principal or midship section, which thus becomes a general index to the form so far as it may be determined by the sections. The usual form of midship section for motor boats shows a moderate to well marked rise of floor, as in Figs. 36 and 34, with a well-rounded bilge and side, often sloping outward slightly at the water line and rising to the vertical near the rail. Within this general type the variations in form of midship section are determined not so much by requirements of speed as by minor or secondary considerations. Thus, if especially shallow draft is desired the midship section will have a rather flat floor, with relatively less rounding off on the bilge, and consequently a high midship section coefficient. On the other hand, if deep draft on moderate displacement is desired, the form of midship section will tend toward the "peg-top" type, that is, with sharp rise of floor and well rounded bilge. In general, however, the flat, shallow section is not the most favorable to seaworthiness, nor is the relatively sharp bilge of Fig. 41 as favorable to low resistance as the more rounded form of Fig. 34. For the best combination of speed, seaworthiness and generally desirable qualities, both extremes are to be avoided, and the prevailing form of midship section in such boats is usually found somewhat as indicated in Figs. 36 and 34.

With the torpedo boat type of stern the after sections become shallow as the stern is approached, and relatively full compared with the surrounding rectangle. This, however, does not necessarily denote fullness of form as determined by cross sectional area compared with that of the midship section. It simply means, as already explained, that the fining away is vertical rather than horizontal.

Toward the bow, with both forms of stern, the sections approach the V or U shape, according to the designer's choice. The latter are presumably somewhat more favorable with regard to resistance, while the former, especially above the load water line, will tend to give lifting power to the bow in a seaway, and hence to reduce the pitching and amount of water shipped when running into a head sea.

Having thus discussed the various geometrical plans and projections and coefficients of form, we may undertake consideration of the problem of actual design. It should first be noted that but rarely is such a design absolutely new and without a more or less direct dependence on previous forms. The accumulation of such forms in any drawing office furnishes a series of starting points from which, by slight modifications in various ways, a vast number of derivative forms may be produced, and in this manner the conditions for new problems may be readily fulfilled. Such modifications may be of two kinds: those involving a change in the proportions of length, beam and draft or depth, and those involving a change in some or all of the fineness coefficients as discussed above.

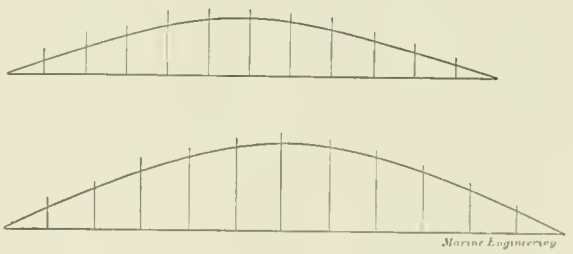


FIG. 42. EXPANSION OF HALF-BREADTH PLAN.

In the simplest possible case it may result that the proportions and form coefficients may all be considered satisfactory. The only change in such case is one of dimension or scale. No new design is therefore required, and the conditions may be realized by a direct increase or decrease of all dimensions in the same ratio. In such case it is not as a rule necessary to make any change on the drawing board or to redraw the lines to the new scale. All such changes may be made when the boat is laid down in the boat shed, and in general manner as will be described at a later point.

A more common case arises in connection with the acceptance of the various coefficients of form, but with requirements which call for some change in the proportions of the three principal dimensions L, B, and H. Thus let us suppose that a given set of lines relates to a boat 24 feet long, 5 feet beam, and 2 feet draft. It is desired to use the same characteristics of form for a boat 30 feet long, 5 feet 3 inches beam, and 2 feet 3 inches draft. The various proportions between the new and old would, therefore, be as follows:

Length ratio $= 30 \div 24 = 1.25$
Beam ratio $= 63 \div 60 = 1.05$
Draft ratio $= 27 \div 24 = 1.125$

This means simply that the new boat is to be 25 percent longer than the old, 5 percent wider and 12.5 percent deeper. Here again no work whatever need be done on the drawing board, as the changes required may all be made when laying the form down full size. The general method of procedure with these ends in view may be outlined as follows:

The first step will be to obtain the new water line or half breadth plan. To this end we note that the intervals between the sections must be increased in the same ratio as the length as a whole. Thus suppose in the original drawing that 12 sections were employed, giving a spacing of 2 feet between each, then the new spacing will be similarly 30 ÷ 12 or 2.5 feet. The ordinates at each end of these stations must then be scaled from the original lines or taken from the so-called table of "offsets" and then multiplied by the breadth ratio 1.05. This will give the lengths of ordinate to be set off at the new stations, and the resulting lines will constitute the new half breadth plan as desired. This operation for a single water line is indicated in Fig. 42. The new length of 30 feet may then be divided into any frame spacing as desired and the locations of the frames drawn in. To determine the form of section at these stations, and hence the actual form of the frames, the vertical spacing of the ordinates must be increased in the ratio of the drafts, or 1.125. If therefore the old spacing was 3 inches the new must be 3 × 1.125 or 3.375. Horizontal lines laid down to this spacing may then be taken as the basis of the body plan, and the ordinates, taken from the new half breadth plan, and laid off on these lines, will give correctly the forms of the sections or frames as desired.

In laying down a new design by this method, and after the form has been determined as above, it may be desired, as a matter of record, to lay down a new set of water planes in the body plan, spaced at some even interval, such as 3 inches. The ordinates taken from such a set of planes may then be made a matter of record in a table of offsets. For such purpose it will be well to distinguish the new set of planes by a different color or by some other arbitrary distinction in order to avoid confusion.

In any such problem of design many practical points will arise which cannot be completely treated in the present brief account of general principles. By the intelligent application of such principles, however, and in the general manner indicated, it will be found a simple matter to lay down a new set of lines having the same characteristics as the initial or type form, but with the proportions of L, B, and H modified in any manner desired. It may sometimes happen that one or more of those ratios may remain the same in the new as in the old form. Thus it may be desired to retain the same ratio of L to B or B to H, or indeed to retain all ratios the same, in which case the change becomes one of size alone, already discussed as the first and most simple case. Again in case the new dimensions are smaller than the old, or some smaller and some larger, the same general principles apply. In short, for all cases, no matter how special, where the form coefficients are to remain the same and a new form is to be derived with new dimensions and new proportions of L, B and H, the same general procedure will serve to determine all features of the new form as may be desired.

Engineering and Shipbuilding Features in Scotland.

Some interesting labor developments have occurred during the year in the engineering trade of this district; and they are of national importance because the Federation of Engineering Employers extends over the whole country, and on any question of principle, or method of procedure, the federation is bound to support any district association against the trades unions. Both the patternmakers and what are called here the engineers (but in America machinists), demanded an advance in wages of ½d. an hour. This was declined by the employers as not warranted by the condition of trade, and also because the contracts which are at present keeping the shops engaged were booked on the basis of existing wages. The patternmakers would not listen to reason, and would not wait for a conference, but went on strike. They thought to corner the employers, but as a matter of fact they have been a stimulus to them. The strike of patternmakers on the Clyde promises to establish a system of mutual aid among the employers which has in it possibilities of great development. When a shipbuilder builds more than one vessel of the same size and type there is, of course, a great saving in office work, in patternmaking, and in other departments of the shipyard; and so in the engine shops. Employers usually endeavor to make one set of patterns suffice for more than one vessel or one set of engines. This plan has been confined to individual works, but the patternmakers' strike has shown that it is capable of expansion by a method of borrowing and lending in the matter of patterns. A pattern received from another firm may not always suit an engineer exactly, but it may be so near as, with very little alteration, to serve his purpose. This idea of uniformity and standardization is steadily spreading among shipowners and shipbuilders. Owners frequently order steamers to be built from the same drawings, not at one yard, but at separate yards. In such cases builders do not think of making two sets of patterns, and the strike on the Clyde has done a great deal to further the idea of mutual assistance of this kind among the associated employers. Thus the strike was frustrated by the free interchange of patterns. Members of the federation were prepared to send their patterns anywhere, so long as they were useful to other members, and the result of this policy will be greater uniformity in the future designing of vessels and engines. The system was got into such good working order that any employer requiring a pattern could know within twenty-four hours whether there was such a pattern in the district, and have it immediately transferred to his shop. The idea was to tide over the dispute, but there is no doubt the matter will be put on a permanent business footing. What with the help of exchanged patterns, the work of apprentices, and devices for making simple castings, without any patterns whatever, the inconvenience of the strike was greatly minimized, and the employers concluded that they would not allow the men simply to walk back at leisure to their work. They would have "terms of settlement" somewhat on the lines of those between the federated employers and the machinists. These terms provide first for local, then for central conferences, pending any dispute, and without cessation of work, and on these terms the present demands of the machinists are being dealt with.

Benj. Taylor.

Gasoline Marine Engines.

Editor Marine Engineering:

The present situation as regards gasoline marine engines is peculiar—to put it mildly—although more apparent perhaps to those who make a specialty of marine work than to others, even the majority of marine engineers failing to appreciate it. The statement, however, of one of them to the writer, covering his views on the subject, nearly hits it, and is as follows:

"The gasoline marine business is surely in a bad mix, and it looks as if most of the manufacturers don't know what a boat that is big enough to be good for anything has to contend with, or what a complete outfit of driving machinery should consist of; and as to the *horsepower*, I don't believe that one in ten has any idea of what this means, but rate their engines to compete with some other fellow, or beat him a little, and consequently bring about a lot of trouble by fooling a customer, even though they don't know that they are doing so."

While this expresses the views of some well-posted marine (steam) engineers, and is unfortunately true, to a surprising extent, there are those building the gasoline engines who fully understand every detail pertaining to the make-up of a first-class outfit of marine machinery, and who must find it difficult to reconcile the rated power of their engines as compared with steam, to the *actual* power transmitted to the propeller or paddlewheel.

Even if we eliminate a few hundred makes by cutting out the small motors entirely, and therefore all of the two-cycle engines, we have an assortment of different designs remaining that must be confusing to the intelligent buyer who is seeking for *the best* and is willing to pay a fair price; for the best gasoline marine engine of to-day is not so much a matter of individual opinion as the buyer might be influenced in believing through reading the

various catalogues and listening to the explanations of the salesmen. The engine itself, or rather *the complete outfit of driving machinery,* must stand on its own merits, and every piece and part of each accessory, as well as the engine itself, must be *right,* in order to insure that dependability which the practical user of steam machinery insists on. Above all other considerations it should be proportioned for and suited to the character of the service in which the boat is to be engaged. Most gasoline engines are designed for light high-speed launches turning a small wheel, barely submerged, at a very high speed, and then calculated as exerting a certain horsepower, but when that engine is actually put to work in a fairly stanch hull, and with a consistent size of working wheel properly submerged, there invariably follows a panicky inquiry as to "where has all the power gone?" It is simply a misapplication, and a different type of engine with longer stroke and slower speed should have been used.

Very few have had the opportunity, and availed themselves of it, as the writer has, to keep continually in touch with the commercial value of medium-size gasoline marine engines (complete outfits) as compared with steam, and the feature that has been most noticeable during the past several years is the effort, that would almost seem to have been made purposely by the gasoline-engine builders, to handicap their own product for the benefit of the marine *steam*-engine builders, by outdoing each other through catalogues and letters, as well as verbally, in offering their product as being practically automatic; requiring little or no attention; always ready at a moment's notice; never any trouble; very economical, and claiming about 50 percent more power than the engine could possibly transmit.

Perhaps this is natural in the evolution of a new power and the conditions under which so many thousand gasoline engines are manufactured, but it was as noticeable twelve years ago as it is to-day; and it would seem as though it were time to call a halt on such statements and offer not only a properly-built and well-equipped complete outfit of gasoline marine machinery, suitably designed for the work it must do, and at a fair working profit, but also *inform the buyer* that it *does* require intelligent attention, and should always receive it, or otherwise that trouble may be expected; furthermore, that the engine cylinders are of a certain diameter and certain length of stroke, and that the power it is able to transmit may easily be determined by him, or by anyone sufficiently interested to figure it out, by simply multiplying the square of the diameter of cylinder by the length of stroke and working revolutions per minute, and then dividing by 15,000 for a one-cylinder engine; double the result for a two-cylinder, and so on; for it has been determined through comparative tests—principally electric—that 15,000 is a conservative, and therefore proper, constant to use.

It would seem unnecessary to touch upon the now well-known fact that the ordinary stationary gasoline engines cannot be turned into so-called boat engines by making a few changes on the main machine, any more than the stationary steam engine can be treated in that manner, although a few years ago it was persistently tried, with some profit to the seller—at a severe cost, however, to the user.

The machinery required is of a character that is designed and built to order to meet the requirements of each particular case, and not to offer a light high-speed gasoline outfit as suited to a heavy business boat, or *vice versa,* but to *fit the case* at a fair price; and when that is done, and not until **then,** will the gasoline marine engine be recognized as a practical working success.

A Builder of Marine Steam Engines.

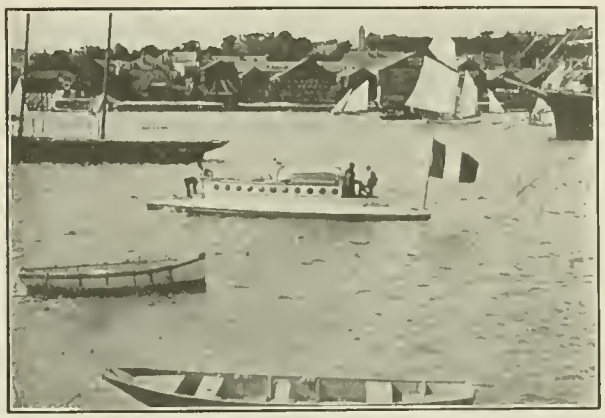
Personal.

W. I. Babcock, late general manager of the Chicago Shipbuilding Company, has been appointed New York representative of the Bath Iron Works, Bath, Maine.

Robert S. Riley has severed his connection with the New York Shipbuilding Company, of Camden, N. J., and become consulting engineer for the Enterprise Transportation Company, at pier 29, East River, New York.

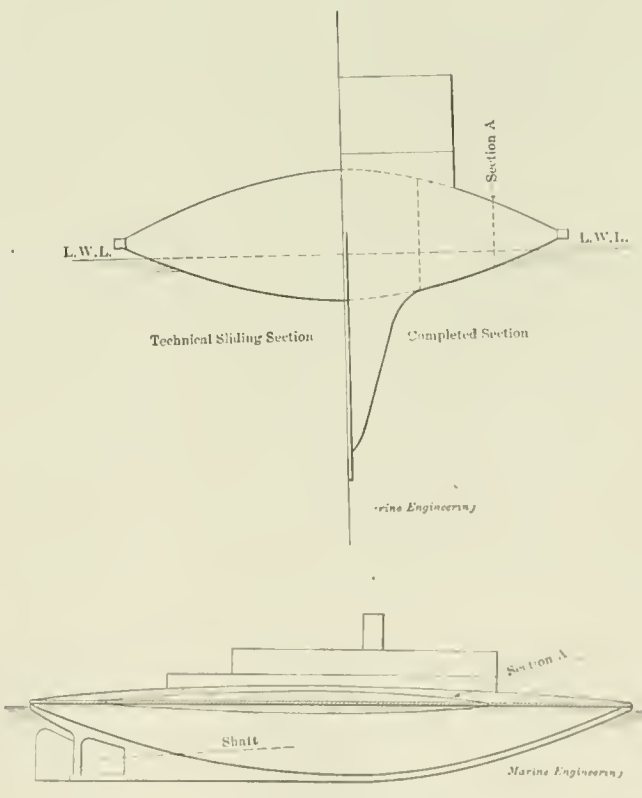
The Motor Boat Slider.

A peculiar model of motor boat, designed to slide over the water, having good stability and a moderate speed, and with an appearance much like a submarine boat, has recently been put into



THE SLIDER UNDER WAY.

service in French waters, and is illustrated in the accompanying cuts. The boat at present in operation has a length of 39 feet 4 inches, a beam of 9 feet 10 inches, and a draft of 5 feet 4 inches, the displacement being about 6 tons. The engines run at 400 revolutions, and with four cylinders develop 66 horsepower, giving a speed of about 13 knots with one form of screw and 9½ knots



SECTIONS AND PROFILE OF SLIDER.

with another. This boat is found to pitch and roll very little under swells and heavy seas, due largely to the peculiar form of the hull. It is built of steel with plates about ⅛-inch thick.

The owner estimates that by building a boat about this same length, with a beam of 13 feet 1 inch, and draft 4 feet 10 inches, and providing it with very powerful machinery, a speed of as high as 32 knots may be obtained.

J. Peltier.

Marine Engineering

Published Monthly by

MARINE ENGINEERING

INCORPORATED.

17 Battery Place, - - - NEW YORK
8 Finsbury Square, - - LONDON, E. C.

H. L. ALDRICH, President and Treasurer

PROF. W. F. DURAND, Advisory Editor

SIDNEY GRAVES KOON, Editor

GEORGE SLATE,
Vice-President and Advertising Representative

Branch Offices. Philadelphia, Pa., Machinery Dept., The Bourse, S. W. Anness.
Boston, Mass., 170 Summer St., S. I. Carpenter.
Chicago, 34 Clark Street, Howard S. Moss.

TERMS OF SUBSCRIPTION.

	Per Year.	Per Copy.
United States, Canada and Mexico	$2.00	20 cents
Other countries in Postal Union	10/6	1/-

Entered at New York Post Office as second-class matter.

Copyright, 1906, by Marine Engineering, Inc., New York.
Marine Engineering is registered in the United States Patent Office.

Notice to Advertisers.

Chonges to be made in copy, or in orders for advertisements, must be in our hands, in New York, not loter thon the 10th of the month, to insure the carrying out of such instructions in the issue of the month following.

The edition of the February issue of Marine Engineering *comprises 5,500 copies. We have no free list, accept no return copies and issue only enough to supply the regular demand, so that the 5,500 copies represent legitimate circulation.*

The Printers' Strike.

As many of our readers are aware, the printing business in New York City is at present in a very precarious position because of a general strike of job printers inaugurated on the first day of January. We do not desire to enter into the ethics of the question, so far as the demand of the union printers for an eight-hour day with their previous nine hours' pay is concerned, but as we are vitally interested in the subject from the fact that our publishers are seriously handicapped by the strike, we think it best to give our readers some idea as to what is going on, and to ask their indulgence in case it should prove difficult or impossible to issue this number (or the next) exactly on time.

The one salient feature in the proposition submitted to the employers by the printers' union, and the one to which the employers most strenuously object, is a demand for what is known as the "closed shop." The ultimate meaning of this expression is that the employing printer could not use in his composing room any man not a member of the union which makes the demand. It further requires that the union should have full authority in stipulating as to what individuals should be so employed. The whole thing has narrowed down into the question of whether a man shall be permitted to run his own business, or whether, on the other hand, he shall submit to having his business run according to the dictation of other parties interested in it only indirectly, taking a thoroughly selfish view of the situation and its requirements, and financially irresponsible, so far as the question is concerned of the placing of legal responsibility for acts committed. It seems to us, as to a great many others who have gone into this subject, that the whole idea of this suppression of individuality and substitution of human machines is entirely un-American in both conception and execution.

We do not wish to be understood as opposing the labor unions, for such is by no means our attitude. We believe that labor unions have done their members and the world in general a great deal of good, and that there is a large field for their continued efforts in this direction; but this fact does not blind our eyes to the equally well-known fact that in very many cases their demands have become not only exorbitant, but absolutely unjust and intolerable, and of such a nature as to give rise to serious doubts regarding their ultimate future. It goes without saying that if they force their employers into bankruptcy, or attempt to force them to accept conditions such as no self-respecting man can accept, their operations will act as a boomerang which will in time destroy themselves, and utterly nullify any usefulness which they may have had in the past.

The second paragraph of the Declaration of Independence states: "We hold these truths to be self-evident, that all men are created equal, that they are endowed by their Creator with certain inalienable rights; that among these are life, liberty and the pursuit of happiness."

It seems to us that the attitude assumed by the Typographical Union in this matter is distinctly at variance with the principle of granting to the employer either liberty or the pursuit of happiness. He is to be deprived of the liberty of conducting his own business in such a manner as to him seems right and just; he is to be deprived of the liberty of employing whom he sees fit; he is to be deprived of the liberty of disciplining employees whose work is below the standard in either quality or quantity. Being deprived of this liberty, it goes without saying that he is thereby deprived of the pursuit of happiness.

In referring to the quantity of work performed by an employee, it might be interesting to note that the rules which the union is attempting to foist upon the employers of this city prohibit the employer from molesting any member of the union (this would include any employee whatsoever, if the closed shop went into effect), for insufficient work in a given period of time, provided the extent of that work is equivalent to a figure stated by conservative authorities to be about fifty-five percent of that which could be done by a good compositor in the time in question. It is needless to state that such a provision as this conduces to laziness, breaks down the character of the man working under it, and might in easily conceivable cases operate to ruin the business of the employer.

The Merchant Marine.

Congress has under consideration the subject of the merchant marine. A bill has been introduced similar in all respects to the one which was side-tracked last spring, and based upon the report of the Merchant Marine Commission appointed more than a year ago. This bill looks to the up-lifting of the merchant marine by means of subsidies or subventions, call it what you will, given to vessels flying the American flag, and depending in amount upon the size of the vessel, and the length of time each year during which it is in actual operation. In addition to this, discriminating tonnage dues, favoring American shipping in the foreign trade, are suggested, the general trend of the total tonnage dues being such as to provide an increased revenue from this source, in order to defray to a certain extent the expense connected with the operation of the subsidy. Provision is also made for the enrollment of a force of naval volunteers, of constantly increasing proportions.

The feasibility of the subsidy is a question which has aroused a great deal of attention, and upon which honest differences of opinion are known to exist. The great difficulty in connection with the opposition to the subsidy lies in the fact that no substitute of any sort has been proposed in such a way as to demand much attention, with the sole exception of the discriminating duties advocated in the minority report presented to congress last spring. It is this very lack of alternative measures which has forced the issue between subsidy and no subsidy, rather than between subsidy and some other scheme for accomplishing the same purpose. There has been no serious disposition to belittle the requirements of the case, because those requirements are universally known and recognized. It has been simply a question as to the expediency of the methods proposed, and much of the question has related not so much to the mere fact of expediency as to the advisability of giving any sort of protection to a single industry.

It may be interesting to note that the virtual withdrawal of the United States from competition in the trans-oceanic commerce of the world has resulted in building up to an enormous degree the merchant marines of several of the other powers bordering on the Atlantic; and that several of these powers are at the present time adding very largely to the immense mercantile fleets which they already possess. During the present month a new ship-owning concern has been floated in Germany, with at first a moderate capital, but with ambitious plans for the future—plans which include a large extension of that capital as trade routes are opened up and developed, and the general trend of progress seems to warrant the increase. A statement issued by the Imperial Marine Office in Berlin, January 4, shows that the merchant marine of Germany advanced from 1,387,000 registered tons on January 1, 1896, to 2,533,000 tons at the present time. This represents an increase of 1,146,000 tons, or 82.6 percent; an increase greater by 250,000 tons than the entire merchant marine of the United States engaged in foreign commerce. The value of the German merchant marine ten years ago was $81,750,000. The present value is placed at $202,500,000. The gain is $120,750,000, or 147.6 percent. This gain was due entirely to the steam tonnage, which is, of course, the most valuable form, both from the point of view of economics and from that of national strength. The increase here was from $63,250,000 ten years ago to $188,250,000 at the present time, being an advance of $125,000,000 or 197.6 percent. During the same period, the value of sailing vessels decreased from $18,500,000 to $14,250,000, a loss of 23 percent.

Figures given by Lloyd's Register of Shipping show that on December 31, 1904, Germany had under construction 69 merchant ships of a total of 178,000 tons; The United States had under construction in coast yards 35 ships of 49,000 tons. Three months later, the German construction amounted to 87 ships of 205,000 tons; the American to 32 ships of 56,000 tons. At the end of June, the German construction was 77 ships of 227,000 tons; the American was 29 ships of 36,000 tons. September 30, 1905, Germany had under construction 72 ships of 225,000 tons; the United States, 26 ships of 38,000 tons. December 31, 1905, Germany had 94 ships of 270,000 tons; United States, 41 ships of 66,000 tons. In no case does the American tonnage above noted exceed 28 percent of that credited to Germany. On every one of the dates in question both France and Italy had a larger tonnage under construction than had the United States, the differences running from 13,000 tons March 31, in the case of each of the above powers, to 35,000 tons, in the case of Italy on June 30. On the latter date even Holland exceeded our construction by 8,000 tons.

We do not wish to institute any comparison between the tonnage under construction in the United States and that necessary to Great Britain. Aside from this one power, however, there is not a single nation in the world which has naturally so great an interest in sea-borne commerce as has the United States; not only are our exports and imports immeasurably superior in both bulk and value to those of any other power, but our coast line is enormous in extent, has many splendid harbors for the reception of ships, offers every facility which nature can offer to the proper development of a mercantile marine. It is simply a question of a difference in wages and in other operative costs between American ships and foreign ships; so long as this difference exists, it will be manifestly impossible to operate American ships in direct competition with those of other powers, and this condition will persist just so long as American standards of living remain superior to foreign standards of living, and no longer. In other words, the rehabilitation of the American merchant marine has come to be a question of either providing governmental assistance to shipbuilders and ship owners, or reducing the American scale of living to standards prevailing elsewhere in the world.

Which shall it be?

ABSTRACTS FROM RULES AND REGULATIONS OF THE GREAT LAKES REGISTER.

EDITION OF 1904.

ARRANGED BY HARRISON S. TAFT.

(Continued.)

2. Double reverse bars are to be fitted on their inner edge, extending from the center line to top of said web.

3. The web plates are to be worked intercostally between the side stringers, being double clipped to same with clips of reverse-bar size, and have in addition a diamond plate connection of the same thickness as the webs. When the depth of the web is 18 inches or below, the diamond plates are to be 24 by 20 inches, but 30 by 24 inches when said depth is above 18 inches.

4. If the web frames between decks are of increased depth they may be of reduced thickness.

44. Side Stringers.

1. Their depth and thickness are to be the same as that of the web frame plates.

2. When cut at a transverse bulkhead they are to be secured to same by a bracket plate of the same thickness as the stringer plates with double clips. Said brackets are to measure on each side at least three times the width of the stringer, being treble riveted to said stringer.

3. When worked continuously through a transverse bulkhead the width of the stringer plate at said point should be increased to double its ordinary width and have double staple work on each side of said bulkhead.

4. Said stringers are to be clipped to the shell plating between the frames; with at least seven rivets in each flange of the clip, when said clip is 4 by 4 inches or above; otherwise 6 rivets. The clips are to be worked double for three frame spaces on each side of a bulkhead.

5. There shall be an angle bar at the face of the reverse bars and on the inboard edge of the stringer and bracket plates unless said plates are flanged.

6. When said stringers are 18 inches or more in depth bracket plates are to be fitted to alternate frames so as to support said stringer plates.

7. See also Table 11.

45. Deck Beams and Knee Brackets.

1. Deck beams are to be of the same scantling as in ordinary vessels.

2. When cut in way of the expansion-trunk sides they are to be secured to same by bracket plates of the same size as those connecting the beams to the frames.

3. Strong beams are to be fitted to the "crown deck" to the head of all web frames, being secured to said web frames by large bracket plates.

4. Hatch-end beams are to be of increased size unless already augmented as stated in paragraph 3.

5. The knee brackets are to be at least three times the depth of the beams they are attached to in way of all oil compartments, having at least a six-rivet connection, spaced not over 4 1-2 diameters apart, to the frames.

6. See also Table 11.

46. Deck Stringers and Plating.

1. The deck stringers are to be worked continuously through all bulkheads. The intercostal clips connecting them to the shell plating are to have at least 6 rivets in each flange.

2. When the gunwale bar on the "crown deck" is worked continuously, it must be of increased size and double riveted in both flanges in way of all oil compartments.

3. In no case shall the "crown deck" be of less than 15 pounds plating, or the top of the expansion trunk of less than 12 1-2 pounds plating.

4. The deck plating must be increased in weight at all hatches, etc. When the upper-deck oil hatchways are worked continuously the strake of plating on each side of said hatchways should be worked double for 1-2 length amidships.

47. Stanchions.

Quarter stanchions are to be fitted throughout when the vessel's beam exceeds 42 feet. One stanchion only need be fitted in each tank unless the length of said tank exceeds 24 feet in a fore-and-aft direction, in which case there shall be two stanchions in each tank.

48. Shell Plating.

1. No reduction will be allowed in the after part of screw vessels up to the counter, when the machinery is located aft. Otherwise (except for the keel plates) the shell plating is to be as for ordinary vessels.

2. Overlapped butts in the way of the oil tanks should be at least treble riveted.

3. Butt straps in the way of the oil tanks are to be worked double and be treble riveted with three complete rows.

4. All longitudinal seams in way of the oil tanks are to be double riveted.

49. Engine and Boiler Space.

1. Web frames in said spaces are to be connected to the tank-top plating by double clips, with a gusset plate riveted to the reverse bars and tank-top plating.

2. When the machinery is located amidships a cofferdam is to be located at each end of said space.

50. Bulkheads.

1. Transverse Bulkheads.

(*a*) Said bulkheads should be fitted with single-frame angles, double riveted in both flanges.

(*b*) The bulkhead-shell liners need only be wide enough to take one row of rivets on each side outside of the frame angle bar.

(*c*) The horizontal stiffeners should be worked in way of the side stringers. They are to be built of plate with a face bar or a flanged edge, and be connected to the bulkhead plating by an angle bar. All as per Table 12. When said plates are 12 inches or more in width they are to be supported by brackets of the same weight as the stringer plates, spaced not more than 6 feet apart.

(*d*) The vertical stiffeners, worked on the opposite side from the horizontal stiffeners, should have bracket plates at their upper and lower ends, connecting said stiffeners to the deck and shell plating respectively.

(*e*) When the vessel's beam exceeds 36 feet a web plate of the same weight as the bulkhead plating is to be fitted to the vertical stiffener, midway between the center line and the sides of the ship on each side. Said web plate is to be at least 24 inches wide at the lower edge, with double angle bars fitted to its outer edge. Said web is to be secured to the deck plating and floors by bracket plates.

(*f*) When the breadth exceeds 42 feet two such webs are to be fitted on each side of the center line.

(*g*) The cofferdam bulkheads must be securely connected to each other by bracket plates, etc. Large bracket plates are to be fitted on the outside of said bulkheads at the floor and bilge stringers.

(*h*) No opening will be allowed in the cofferdam bulkheads below the "crown deck." They are to be treated as an oiltight compartment in all cases.

2. Center-Line Bulkheads.

(*a*) The weight of plating and stiffener scantlings are to be as given for the athwartship bulkheads in Table 12, except for the bottom strake, for which see section 38, paragraph 2.

(*b*) The vertical stiffeners are to be spaced as per frames, being connected at their lower ends to the floor brackets at the center-line bulkhead, and having similar brackets connecting their upper ends to the deck beams.

(*c*) Horizontal-plate stiffeners should be worked in way of the athwartship-bulkhead horizontal stiffeners, being connected to said horizontal stiffeners by bracket plates of the same weight as the plate stiffeners, with a breadth each way measured from the bulkhead of three times the width of the plate stiffener. A bracket plate should be worked on the opposite side of the bulkhead in way of aforesaid horizontal stiffeners.

(*d*) All plating above the lower strake may be worked intercostally between the athwartship bulkheads or continuously through them as desired.

(*e*) A vertical plate stiffener, equal to the weight of the bulkhead plating, is to be fitted the full depth of said bulkhead in way of the web frames at the side of the vessel. Said web plate shall be at least 2 feet wide at the lower edge, with a face angle of reverse-bar size, and be bracketed to the floors and deck beams.

(*f*) The extreme ends of a longitudinal bulkhead must taper for a distance at least equal to 1-3 of its depth from the keel to the "crown deck."

(*g*) When said bulkhead extends up into the expansion trunk, it may be 2 1-2 pounds less in weight within said space than the trunk's side plating, with stiffeners of reverse-bar size spaced as per frames, unless the bulkhead is made oiltight, in which case its scantling and that of its stiffeners must equal that of the trunk side plating.

3. It is recommended that the bulkhead plating be caulked on both sides, together with their stiffener angles.

4. Oiltight bulkheads must be made oiltight without the use of felt, packing, or lead.

TABLE 12.—SCANTLINGS FOR LONGITUDINAL AND TRANSVERSE OIL-TIGHT BULKHEADS.

Numbers B + D	Weight of Plating. Lbs.			Horizontal Stiffeners.		Vertical Stiffeners.		
	Lower Third	Middle Third.	Upper Third.	Breadth and Weight of Plates.	Size of Angles.	Bulb Angles. Size.		Maximum Spacing.
42 to 46	15	14	12⅛	9 inches × 14 lbs.	3 × 3 inches × 7.2 lbs	5 × 3 inches × 9.8 lbs.		24″
46 " 52	16	15	14	10 " × 15 "	3 × 3 " × 7 2 "	5½ × 3 " × 12.3 "		24
52 " 56	17	16	15	10 " × 16 "	3½ × 3½ " × 8.5 "	6 × 3 " × 12.3 "		25
56 " 60	18½	17	15	11 " × 17 "	3½ × 3½ " × 8.5 "	6 × 3 " × 13.75 "		25
60 " 64	20	18½	16	12 " × 18½ "	3½ × 3½ " × 8.5 "	6½ × 3½ " × 17.2 "		26
64 " 67	20	18½	16	13 " × 18½ "	3½ × 3½ " × 9.8 "	7 × 3½ " × 18.0 "		26
67 " 70	21½	20	17½	14 " × 20 "	3½ × 3½ " × 9.8 "	7 × 3½ " × 19.25 "		27
70 and above	21½	20	17½	15 " × 20 "	3½ × 3½ " × 9.8 "	7 × 3½ " × 19.25 "		27

51. Expansion Trunks.

1. The plating of said trunks is to equal that of the upper part of the tank bulkhead, as per Table 12.

2. The stiffeners are to be of the same scantling as the frames and be located in way of the deck beams. They are to be bracketed to said beams at both top and bottom by knees of the same thickness as the flange of the stiffeners to which they are attached.

3. Web plates of the same thickness as the trunk side plates are to be fitted at the ends of all hatchways.

4. Fore-and-afters are to be fitted in way of all half-beams where the deck plating is flanged in way of an expansion trunk.

52. Riveting.

1. Rivets of less than 3-4-inch diameter will not be allowed in oil tanks subject to pressure.

2. Widths of butt straps, etc., to be the same as for ordinary vessels, as per Table 7 and sections 20 and 21 of Part I., except as noted below.

3. Single-riveted longitudinal shell seams will not be allowed in way of an oil compartment.

4. If the center-line bulkhead is not made oiltight, all seams and butts of same, except those of the bottom strake, can be single riveted.

5. Butts of the "crown-deck" plating are to be double or treble riveted as called for.

6. The Following to be Double Riveted:

(*a*) Butts and seams of all oiltight bulkheads. Chain fashion.

(*b*) Upper edge of the lower strake of plating of the center-line bulkhead in all cases.

(*c*) Oiltight-bulkhead frame bars; corner angles; and collars subject to oil pressure. Zigzag fashion.

(*d*) Longitudinal seams of the "crown-deck" plating. Chain fashion.

(*e*) Knee brackets; bracket plates in general when worked to maintain continuity of strength. Zigzag fashion.

(*f*) Single frame bars at web frames. Zigzag fashion.

(*g*) Web-frame butts.

7. The Following to be Treble Riveted:

(*a*) All butts of the lower strake of a center-line bulkhead.

(*b*) Web frames to floor plates.

8. In oiltight bulkheads and in all other parts, where the oil pressure comes from both sides, and in cases where more than two thicknesses of plates are riveted together, it is recommended that rivets with countersunk heads as well as points be used, or else the plug-neck type of rivet be substituted. The head of the rivet should project beyond the plate at least 1-4 of an inch, with sufficient spread on said head to prevent it from being drawn.

53. Spacing of Rivets.

	DIAS.
1. Longitudinal seams of the shell plating; butts and seams of the "crown-deck" plating; butts and seams of all bulkheads made oiltight; chain riveted	3½
2. Oiltight-bulkhead frame bars; corner angles and collars; bulkhead stiffeners to be caulked	4
3. Butts and seams of a center-line bulkhead not made oiltight; deck-beam knee brackets; all bracket plates worked to maintain continuity of strength	4½
4. Bulkhead stiffeners not caulked	6
5. Frame and deck-beam rivets	6½
6. Single frame bars at web frames. Zigzag riveted	7

7. Side-stringer shell clips; 7 rivets in each flange when of 4 by 4 inches, but 6 rivets if of less size.

8. Deck-stringer shell clips; 6 rivets in each flange.

9. Deck-beam knees; 6 rivets in each knee.

See Table 7, Part I.

PART III.

54. 36-Inch Frame Spacing.

1. The extent of a 36-inch frame spacing is to be from the forward collision bulkhead to the bulkhead at the forward end of the engine room when the machinery is located aft. When the machinery is located amidships said 36-inch frame spacing can be worked throughout said machinery space.

2. When the engines are located aft the frame spacing throughout the engine room and aft peaks must not exceed 24 inches.

3. The regular frame spacing in the fore peak must not exceed 24 inches with intermediate frames as in ordinary vessels (Section 6, Part I.).

If the regular frames are spaced 18 inches apart these intermediate frames may be dispensed with.

4. With a 36-inch frame spacing the shell plating must not be less than 3-8 inches thick (15 pounds). When the shell plating is less than said thickness the frames must not be spaced more than 24 inches apart.

5. The frames, floors, and reverse bars throughout the engine-room space, when located aft, are to be as in ordinary vessels.

6. (*a*) When the sum of the beam and depth (B + D) is under 82, web frames will not be required outside of the engine-room space; but it is recommended that web frames, spaced not over 15 feet apart, be fitted in the forward cargo hold when said sum is 76, 78, or 80.

(*b*) When said sum is 82 and 84, the above web frames are to be fitted throughout the cargo space, being spaced 24 feet apart. When said sum is 86 and above, they are to be located at each hatch beam.

(*c*) The web frames in the engine room are to be spaced not over 12 feet apart.

7. The spacing of the hold stringers, and the between-deck side stringers, should be such that they will not be more than 4 feet 6 inches apart or from a deck amidships; so that the area of unsupported shell plating at the forward and after collision bulkheads will not be over 18 superficial square feet, said stringers being chocked to the shell. When said area is over 20 superficial square feet, panting stringers must be fitted.

PART IV.

55. Stowage of Grain.

1. When the vessel is not fitted with a double bottom, a grain-tight raised platform must be fitted a sufficient distance above the floors, so as to allow a free flow of the bilge water to the pumps. In flat-bottom vessels said platform must be 10 inches above the floors at the center line and 12 inches at the bilge.

2. Vessels of 35- to 40-foot beam are to have a center-line shifting board extending from the under side of the upper-deck beams to half depth of the hold. When built of wood they are to be at least 1 inch thick, being secured to the center-line stanchions. When said stanchions are spaced over 4 feet apart the shifting boards must be made thicker in proportion.

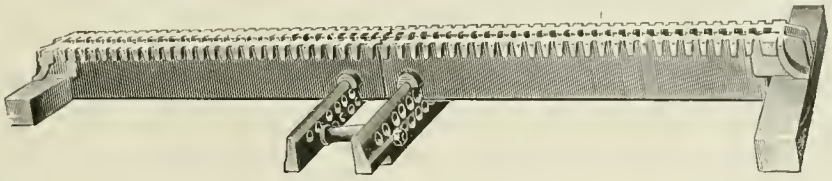
3. When said beam is 40 feet and above, two such longitudinal lines of shifting boards are to be worked, each located midway between the center line and the side of the ship, the above center-line shifting board being omitted.

4. When a second deck is fully laid and depth of hold below said deck exceeds 10 feet, a center-line bulkhead or partition should be fitted below said deck to 1-2 depth of hold.

ENGINEERING SPECIALTIES.

The Barker Grate Bar.

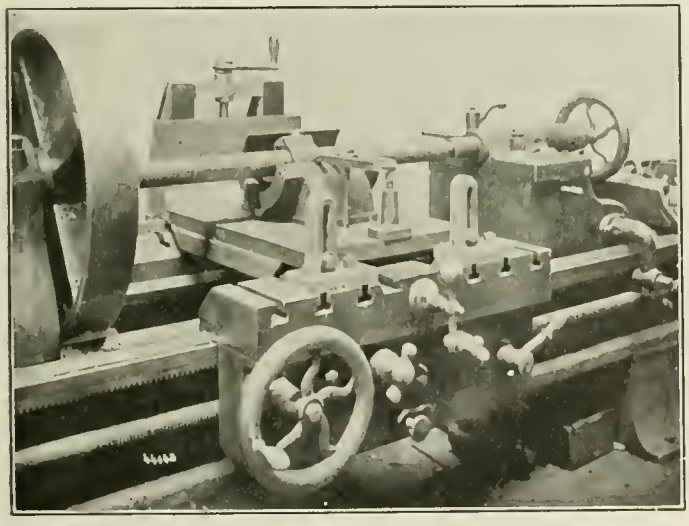
In this bar the first advantage to be noted is the great percentage of air space and its even distribution over the entire grate surface. The air is not obstructed by any braces, spacing lugs or blank spaces on the grate surface, there being a clear, open line of air between the bars from one end to the other. The illustration shows clearly these important features. The bar is one which offers much less obstruction to combustion than other kinds and as a result effects a saving of coal that soon makes the first cost a secondary consideration.



It is a twin bar with the lower edge of the webs united by two braces, placed well below the heated surface and consequently always cool. The braces hold the bars rigidly against warping, and yet do not interfere with the free passage of air. In order to avoid the possibility of the rake catching in the joint between the front and rear sections of the bars where they meet over the middle bearing bar, one bar in each twin bar is made slightly longer than the other, so that when the complete grate is assembled a zigzag joint is formed across the grate. The bar is placed upon the market by the Robsmith Specialty Company, Provident Building, Philadelphia.

Lathe Attachment for Boring.

An attachment for converting a lathe into a horizontal boring machine is the new product of H. B. Underwood & Co., 1025 Hamilton street, Philadelphia. The attachment is placed in the position ordinarily occupied by the cross slide, which must be removed when the lathe is to be used as a boring machine. It serves the same function as the work table of a horizontal boring



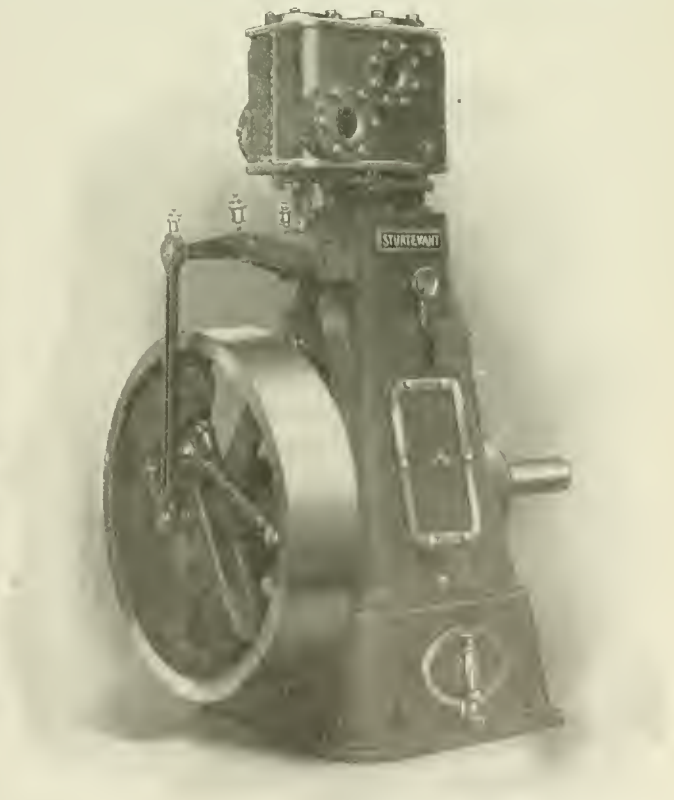
machine and is adjustable laterally and vertically. The boring tool is mounted on a bar supported between the head and tail of the lathe. It is claimed that the work done is in every respect equal in quality and quantity to the output of a regular boring mill of equivalent capacity.

The attachment consists in the main of two castings; one, resembling in miniature the housings of a boring mill or planer, is attached to the rear of the lathe carriage, and the other is a horizontal table plate having a vertical leg adapted to slide on ways planed on the rear casting. The surfaces of this angle plate are planed square or parallel with all the other parts of the attachment. The vertical adjustment of the table plate on the supporting casting is effected by an adjusting screw. The bed of an attachment for a 30-inch lathe has three T slots for ⅝ or ¾ inch bolts, is 31 inches long by 22½ inches wide and has a vertical adjustment of 5½ inches.

This attachment may be readily fitted to any lathe, it being necessary only to remove the tool slide and drill and tap the holes in the back of the carriage for securing the upright casting. Thereafter the time required to change the lathe from a turning to a boring machine is covered by a very few minutes. The weight of the attachment for a 30-inch lathe is 685 pounds. For this size a 3 or 3¼ inch boring bar with suitable cutter heads and automatic feed is recommended.

Sturtevant Vertical Engines.

One of the features of the Sturtevant vertical engine (Hyde Park, Mass.) is a system of forced lubrication, which, with the



complete inclosure of the moving parts, provides for continuous operation for weeks at a time without attention, and it is said insures

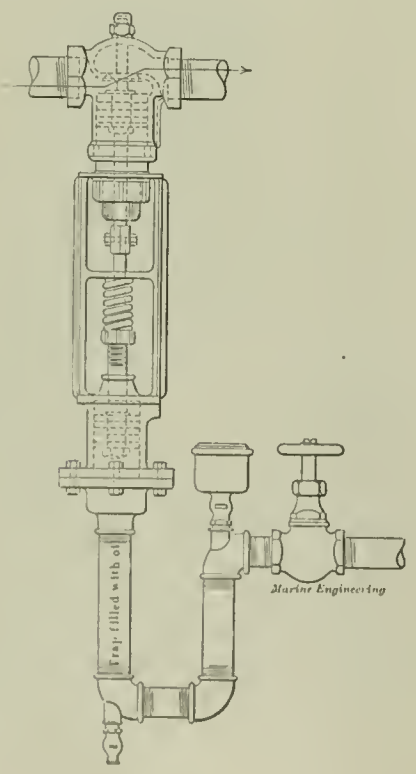
perfect reliability even in the hands of the unskilled. This type of engine is adapted to all classes of work requiring maximum power in minimum space, a condition attained by operation at the high speed made possible by refined design, high-grade construction and the use of the best material. They are especially designed for the driving of direct-connected generators. Because of the large diameter and short stroke, they develop great power and high rotative speed without excessive piston travel.

Within the heavy cast-iron base, to which is bolted the lower part of the frame, a submerged oil pump, operated by the crank shaft, draws oil from the reservoir and forces it through pipes and internal passages in the moving parts to the crank pin, the wrist pin, and the main bearings. Twice during each revolution the reversal of stress on these parts, due to the double-acting feature of the engine, so reduces the pressure that the pump has an excellent opportunity to force between the surfaces a fresh film of oil, which is carried around to lubricate the rotating parts, when the pressure is greater. The pressure of 10 to 20 pounds per square inch maintains this film of oil, preventing actual contact with metal, reducing wear and friction to a minimum, and insuring a mechanical efficiency of over 90 percent.

The engine is built in sizes ranging from 6 to 85 horsepower, depending upon the steam pressure employed. The weights vary from 1,000 to 4,300 pounds, and speeds of revolution from 475 per minute in the smaller sizes to 275 in the larger.

The Ideal Automatic Pump Governor.

For the purpose of maintaining a pump in a condition always ready for any emergency this governor has been placed upon the market by the Ideal Pump Governor Company of 15 Whitehall street, New York. One of the main features consists in the fact that the piston and water pressure cylinder are protected from corrosion and from sticking by means of a body of oil which follows the piston on both strokes, and thoroughly lubricates all

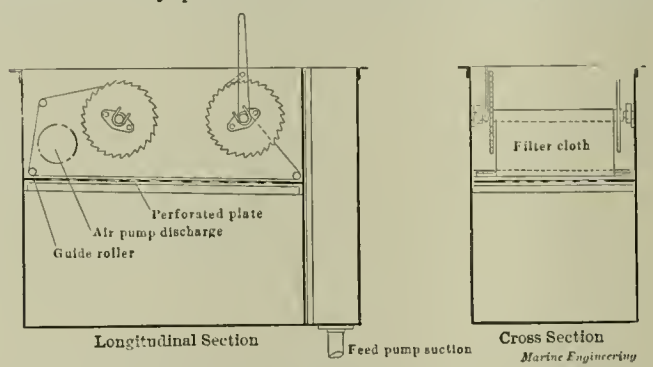


wearing surfaces in the cylinder. This makes it virtually impossible for the pump to stick at a time when an emergency requires that it be used, as well as provides a great saving in wear and tear and in consequent repairs. The spring shown in the illustration operates to start the pump working at any time when the pressure in the stand or delivery pipe falls below a predetermined value, and when this pressure reaches the proper figure the oil is pressed against the piston and the throttle valve shut against the pressure spring. It is seen that this action is automatic.

An illustration of the value of this sort of equipment was afforded early in December when the steamer *Rosalie* of the Joy Line was discovered to be on fire in the berth next to that occupied by the United States transport *McClellan*. On the latter ship this governor was fitted, and operated to govern the pump in such a way that it was not necessary to pass word back and forth between those fighting the fire and those in the engine room of the transport, it being found that the pressure, which was set for 100 pounds per square inch, was easily maintained on the line until the fire was out. No time was lost in getting the pumps started, it being necessary simply to connect the hose and open the stop valves.

The Milne Filter.

By means of a roll of towelling, or any other fabric which will allow water to pass freely through it, a simple filter arrangement has been perfected and patented by J. S. Milne of the Neafie and Levy Shipbuilding Company of Philadelphia, and tested upon the steam yacht *Josephine*. The filter cloth is stretched across a wire screen or perforated plate, with plenty of lap at the ends and sides, and, being provided in a roll of thirty or forty yards in length, it is seen that once installed the equipment is virtually permanent for a considerable length of time.



When the cloth becomes so saturated with material taken out of the water that the latter will not readily pass through it, a handle is turned, shifting the saturated portion to a receiving drum and supplying new material for the operating portion of the filter. It is estimated that under ordinary conditions a roll will last from forty to fifty days of continuous steaming, with little more attention than the changing of the cartridge. Tests have shown that this filter catches practically every bit of the oil and other impurities in the water, as well as matter in suspension, such as mud and sand. It can of course readily be made automatic by attaching to the receiving roll either clock work, or some other motive device.

TECHNICAL PUBLICATIONS.

The Shipbuilding Industry; Its History, Practice, Science and Finance. By David Pollock, M. I. N. A. Size 5 by 7½ inches. Pages 199. 1905. Methuen & Company, London. Price 2/6 net.

Beginning with the earliest history of shipbuilding, dated far back of the time of Noah's Ark, and carrying the reader through the Roman and Norseman epochs, this work covers the history of the subject from the very beginning up to the present time, giving quite a little information regarding early questions relating to steam propulsion, and the first successful examples of steam vessels.

The second chapter is devoted to the development of the modern steamship, from about the period of the *Great Eastern*, giving a number of illustrations, nearly all half tones, showing various features of the ships and of their construction, and carrying the subject up to the advent of the marine steam turbine in large ships. The next subdivision covers the subject of shipbuilding in up-to-date ship yards, going into some details regarding the preparation of the frames and plates, together with the subjects of punching, shearing, riveting and the crane equipment of the yards. This gives also some information regarding model tanks and their uses. The fourth chapter is devoted to evolution in structures and types of ships, and includes comments upon the types known as turret ships, together with the use of steam turbines as a means of propulsion. The last chapter deals with the volume and sources of output and the general classes of shipping forming that output, covering all the tonnage-producing districts and countries on the globe. In this chapter are given tables of production covering a number of years, not only in Great Britain, but in all the other countries in which shipbuilding is carried on. The illustrations are all printed on inset sheets, and with two exceptions consist entirely of half tones. They are very well chosen and contribute much to the value of the work. There is one folder giving a longitudinal section of the new Cunard ship *Caronia*. The good index at the rear of the volume ought to be appreciated.

Elementary Mechanics. By George A. Merrill, B. S. Size 5½ by 8 inches. Pages 267. Illustrations 175. 1905, New York. American Book Company. Price $1.50.

Intended for the upper classes in elementary schools and the lower classes in college, this book is essentially an elementary text book, presupposing the completion of work in trigonometry, but not requiring for its development the use of the calculus. It has, of course, nothing like the scope of the larger and more pretentious works on the subject such as are used in our large engineering colleges, but it is much more adequately prepared for the purpose than is the case with the portion of the physics works devoted to the subject of mechanics, even including those used in colleges. It is subdivided into the logical sections of kinematics, statics and kinetics; under each of which heads the explanations and proofs are given with a great deal of care, and examples are given covering the range of the material in the text. The illustrations, almost entirely linear, are clear and well chosen for the purpose.

Record of American and Foreign Shipping. Pages 1,322. Size 8 by 9½ inches. Price $15.00. American Bureau of Shipping. 66 Beaver street, New York.

The volume for 1906 of the "Record of American and Foreign Shipping" (American Lloyd's), which is the thirty-eighth annual issue of this valuable register, is now being delivered to subscribers.

The Record contains full reports and particulars of 14,645 vessels, ranging from the ketch to the full powered trans-Atlantic liner, and flying the flag of every nation, alphabetically arranged, with much detail as to build, ownership, and condition. This information forms the bulk of the annual volume, but it also contains rules for the construction and classification of all classes of vessels, with illustrations and tables of great technical and practical value; revised rules for the construction of machinery and boilers, electric installations and refrigerating apparatus on shipboard.

The volume contains names of vessels which have been changed; list of compound names arranged alphabetically by last word of name, for ready reference; list of addresses of prominent shipbuilders, drydocks and marine railways of the United States; list of owners of vessels, all of much value to the shipping interests. The work is approved and indorsed by the important boards of underwriters of the United States, and is accepted by the merchants and underwriters throughout the world as a standard classification of shipping. Supplements to the volume, issued semi-monthly, keep subscribers informed of new vessels constructed during the year, with reports of repairs to old vessels, and other useful information.

QUERIES AND ANSWERS.

All reasonable questions concerning marine engineering received from and signed by subscribers will be answered by the Editor in this column. All communications must bear the name and address of the writer.

Q. 310.—Please answer the following questions regarding good practice in the design for purpose of cooling any space:

(1) How much pressure is necessary to liquefy carbonic acid gas at 65 degrees Fahrenheit.

(2) If copper and iron pipe be acted upon by carbonic acid gas, by what means can it be protected?

(3) Under what pressure may the carbonic acid gas on the market be stored?

(4) How much quantity of gas can be accumulated to a jar?

S. W.

A.—(1) The pressure required to liquefy carbonic acid gas ranges from about 680 pounds per square inch at 50 degrees Fah. to 1,000 pounds at about 80 degrees Fah. At 65 degrees the pressure required will be about 830 pounds per square inch.

(2) Carbonic acid does not attack copper or iron, and this fact, together with its lack of chemical activity toward most food substances is one of the points of advantage which this substance may claim as a refrigerating agent.

(3) The answer to (1) will sufficiently answer this question.

(4) The jars or cylinders usually contain from 20 to 22 pounds of liquid carbonic acid.

Q. 319.— Will you place me on the right track as to the calculations for a gasoline engine and let me know how the following elements are obtained? The engine is to be of the four-cycle type with three cylinders, 5-inch bore, 5-inch stroke; 800 revolutions per minute.

(1) Area, or depth of the compression space.
(2) Area in square inches of the admission valves.
(3) Area in square inches of the exhaust valves.
(4) Thickness of cylinder walls.
(5) Length of connecting rod.
(6) Approximate horsepower.

A.—(1) The volume of the compression space will be from 30 to 35 percent of the piston displacement; in this case being about 33 cubic inches for each cylinder.

(2) The area in square inches of the admission passage will be represented by the formula $a = \frac{NV}{36{,}000}$, where N represents the number of revolutions per minute and V is the piston displacement in cubic inches. In the example in question $a = 2.2$ square inches, representing a diameter of nearly 1¾ inches.

(3) The area of the exhaust passage should be 30 or 40 per cent greater than that for admission, though in many cases they are made of the same size. For the present case this would figure out at 3 square inches, giving a diameter of 2 inches.

These three questions were answered at some length on page 441 of Marine Engineering for October, 1905.

(4) An expression for the thickness of cylinder wall is given on page 153 of Lucke: "Gas Engine Design," as $t = 0.075d$. In the present case this figures out at ⅜-inch.

(5) The length of connecting rod is commonly made from five to six times the length of the stroke. In the present case that would mean from 13 to 15 inches.

(6) The approximate horsepower is found from the formula $H = \frac{PLAN}{33{,}000}$. In the present case the result is about 24.

Q. 324.—Will you please give me a formula for determining the correct equivalent mean effective pressure in the low-pressure cylinder of a compound or triple expansion engine? M. E. P. $= \frac{p\ (1 + \text{hyp. } r)}{r}$ gives the theoretical value, while some authorities give $\frac{.9 \times p \times (1 + \text{hyp. } r)}{r} - .9p$

as the real value, but this I find about 20 to 30 percent too high, according to results given in tables. J. G. R.

A.—For a single cylinder engine the M. E. P. is found from the expression $p\ (1 + \text{hyp. } r) - p$ where p is the initial pressure of the steam in pounds per square inch, p is the back pressure of the steam, and r is the ratio of expansion in the cylinder.

For an engine having more than one cylinder, the mean effective pressure as reduced to the low-pressure cylinder is found from the same expression, but in this case it is necessary to employ a reduction factor to cover the fact that from one cylinder to another there is a loss in effective pressure due to the necessary pressure gradient for carrying the steam through the steam passages, and a further loss due to condensation of the steam in those passages and to radiation. General practice places the multiplying factor for a compound engine at from 0.8 to 0.9, with an average of perhaps 0.85; for a triple expansion engine this "card factor," as it is called, becomes from .65 to .75, with an average of perhaps .7; the corresponding figure for a quadruple expansion engine is placed at .55 or .60; the exact value in each case being determined by a consideration of the qualities of the engine with regard to design.

Q. 327.— There is a watertight compartment 12 by 12 feet and 8 feet high through which the rudder post, 21 inches in diameter, passes. The stuffing box, which is 7 feet below the surface of the water, is leaking so that it takes a pipe 1½inches in diameter to drain it off. As they do not want to dock the ship the engineer in charge proposes to pump air into it at such a pressure as will overcome the leakage by forcing the water back through the stuffing box, while a man stays in there and packs the gland. Would you kindly answer, what pressure would be required to do it; and against what pressure of air a man could work while in a place like that? This occurred on board a warship.

W. H.

A.—If we understand the question aright, the head of water under which the leakage occurs is 7 feet, and the pressure due to such a head of water figures out at a trifle more than 3 pounds per square inch. It is quite a common practice for men in constructing submarine tunnels, such as those now being driven beneath the Hudson river and East river at New York, to work in a pressure amounting to one atmosphere above the regular air pressure, and in many cases it is necessary to increase the pressure in the compartments in which the men are working to two or more atmospheres. One atmosphere represents a pressure of 14.7 pounds per square inch, which is nearly five times that required in the case mentioned, and while the effects are not particularly bad, yet there is a certain amount of discomfort connected with such a pressure. This would probably not be the case with any pressure less than 6 or 8 pounds per square inch. The scheme proposed for the stoppage of the leakage is not only feasible, but is one which has been used for other purposes in a great many cases.

Q. 328.— There is a gas engine with cylinder diameter 2⅝ inches and a 3-inch stroke. The combustion chamber contains 2.55 cubic inches. There are two balance disks weighing 4 pounds each and being 6 inches in diameter. What is the proper size and weight for a fly wheel? The engine is supposed to run 300 to 400 revolutions.

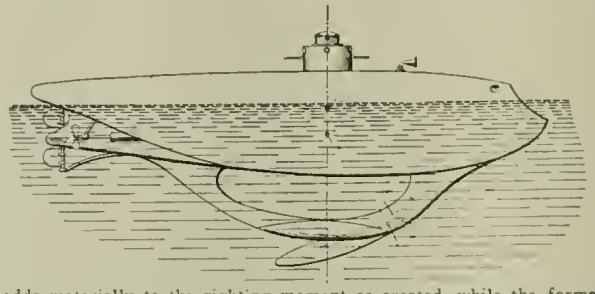
P. A. DeL.

A.—Without knowing something about the action of this engine with regard to smoothness of working and particularly with regard to the crank effort diagram, it would be out of the question to give an answer to this query. Makers of engines of this character doubtless fit fly wheels which have been found by practice to cover the case sufficiently well, without taking the trouble to go into the mathematics of the question and determine accurately the proper size and weight for such a wheel, and such a method of procedure gives quite satisfactory results, although in many cases it is a question of guesswork rather than a real knowledge of the requirements of the case. The information given by our correspondent is not sufficient for a mathematical determination of the size and weight of fly wheel, because, as stated above, it would be necessary to know the exact history of the crank effort through the continuance of a complete cycle; and to know further within what limits of variation in momentary speed it was proposed to run the engine.

SELECTED MARINE PATENTS.

803,172. SUBMARINE VESSEL. SIMON LAKE, BRIDGEPORT, CONN.

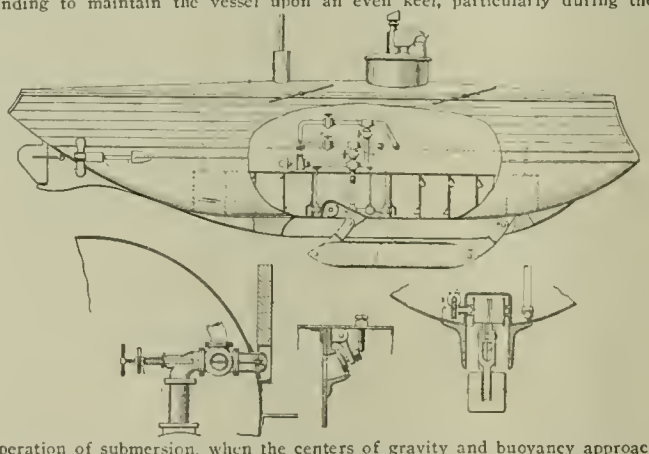
Abstract.—The invention consists, essentially, in the combination, with the hull, of a depending web or support which sustains a weight at some distance below the lower side of the hull and beneath its center of buoyancy. By locating the weight outside of the hull and maintaining it in a fixed relation thereto the center of gravity of the boat as a whole is lowered to such a degree beneath the center of buoyancy that a decided tendency is created to preserve the boat in its normal fore and aft trim and which opposes any relative vertical movement by the bow or stern during submergence. The addition of a conning tower upon the upper side of the



hull adds materially to the righting moment so created, while the formation of the depending weight into a rigid and a depending hinged section enables the latter to perform the additional function of relieving the boat of a portion of its ballast when dragging upon the water bed and to thus serve as a yielding runner for causing the boat to follow the contour of the water bed when desired without danger of its striking the latter or any small obstruction thereon, and so damaging its hull. Four claims.

803,173. SUBMARINE VESSEL. SIMON LAKE, BRIDGEPORT, CONN.

Abstract.—This invention has for its object to secure in the construction of submarine boats a greater fore and aft stability. To that end the pressure resisting hull of the vessel is provided with a buoyant deck, preferably spaced materially above the same, and, therefore, affording in respect of the center of gravity of the hull a moment of considerable magnitude tending to maintain the vessel upon an even keel, particularly during the



operation of submersion, when the centers of gravity and buoyancy approach each other somewhat under the changing conditions occurring in the course of such operation. To insure a comparatively large displacement for the upper portion of the vessel, not only is the deck preferably constructed of wood planking suitably calked to insure against penetration of water, but the sides of the superstructure are made of like material, thus providing an entire superstructure of buoyant material and preferably of buoyant construction. Fourteen claims.

803,174. BALLAST DEVICE FOR SUBMARINE VESSELS. SIMON LAKE, BRIDGEPORT, CONN.

Abstract.—According to the present invention the vessel is provided with a flat guide plane or planes substantially parallel with the direction of thrust of its propelling means and comprising a comparatively flat deck or lateral guards or fins along the edges, or both, in combination with a heavy ballast weight which is movable longitudinally in respect of the center of gravity of the hull, the shifting of which forwardly or backwardly operates to give the vessel a slight upward or downward inclination in opposition to the steadying tendency of the guide plane or planes, and thereby cause the vessel to rise toward or descend from the surface. By suitably suspending the ballast weight it is also adapted to serve the additional function when lowered materially beneath the hull into its normal position beneath the center of gravity of correspondingly lowering the resultant center of gravity of the component parts of the structure. Six claims.

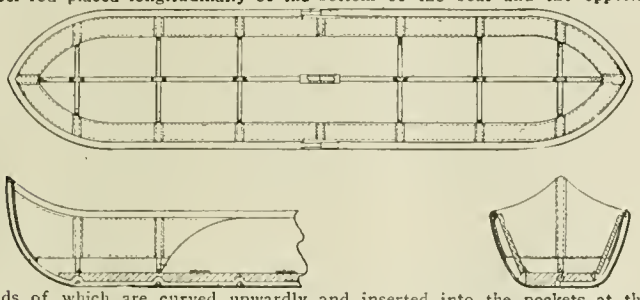
803,175. BALLAST APPARATUS FOR SUBMARINE VESSELS. SIMON LAKE, BRIDGEPORT, CONN.

Abstract.—The present invention further provides for the positive cutting off of communication between the filled and unfilled or partially filled tanks of the system by locking the intervening overflow check valve, so that the pitching or carcening of the vessel from any cause shall not effect the shifting of the water ballast to any appreciable extent, and thereby injuriously affect the equilibrium of the vessel. Thirteen claims.

803,272. BOAT. JOHN F. CONKLING, HAWLEY, PA.

Claim.—3. A boat, the body portion of which is composed of flexible material and provided at the top of the side and end portions thereof with pockets, the opposite sides of the boat being also provided with transversely arranged pockets, top side rods composed of separate parts inserted into the

top side pockets centrally of the boat and the opposite ends of which are curved inwardly, and the adjacent ends thereof rigidly connected, a bottom keel rod placed longitudinally of the bottom of the boat and the opposite

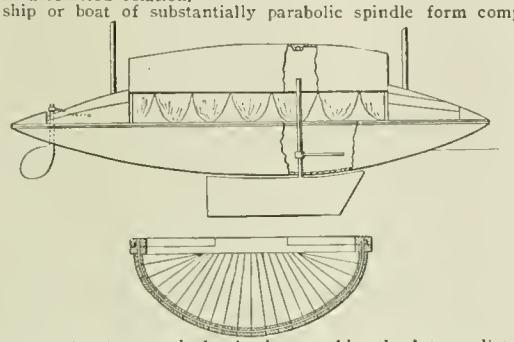


ends of which are curved upwardly and inserted into the pockets at the opposite ends of the boat, said bottom keel rod being also composed of separate parts rigidly connected and transverse ribs or knees the ends of which are curved upwardly and inserted into transverse pockets in the opposite sides of the boat, said boat being also provided with a supplemental bottom which rests on the bottom keel rod and transverse ribs or knees, and which is composed of two parts hinged together. Four claims.

803,607. BOAT OR SHIP. CHARLES P. LEAVITT, MIAMI, FLA., ASSIGNOR OF TWO-THIRDS TO ARVID P. CURRY, MIAMI, FLA.

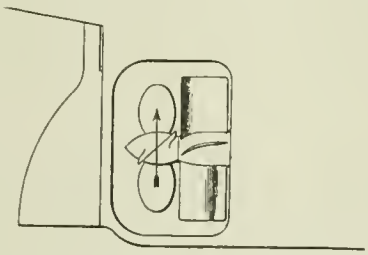
Claim.—1. A ship or boat of substantially parabolic spindle form, comprising a hull and a superstructure, each composed of a plurality of staves arranged side by side, and rods extending transversely of the hull and superstructure and constituting the sole means for holding the staves together in assembled relation.

5. A ship or boat of substantially parabolic spindle form comprising a



hull and a superstructure, and also having a cabin, the intermediate part of the superstructure constituting a roof for the cabin, divided bulkheads in the ship or boat, one section of each being connected with the intermediate part of the superstructure and the other part with the hull, and means for raising said intermediate part of the superstructure. Nine claims.

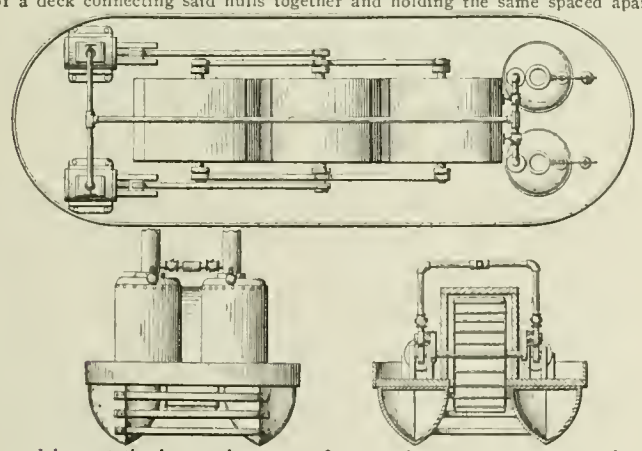
803,671. MARINE PROPELLER. CHARLES G. CURTIS, NEW YORK.



Claim.—1. The combination with a marine propeller, of curved or inclined stationary guide-blades located in front of the propeller and radiating from the propeller-shaft. Five claims.

803,768. STEAMBOAT. JEREMIAH LOCKWOOD, SULLIVAN, IND.

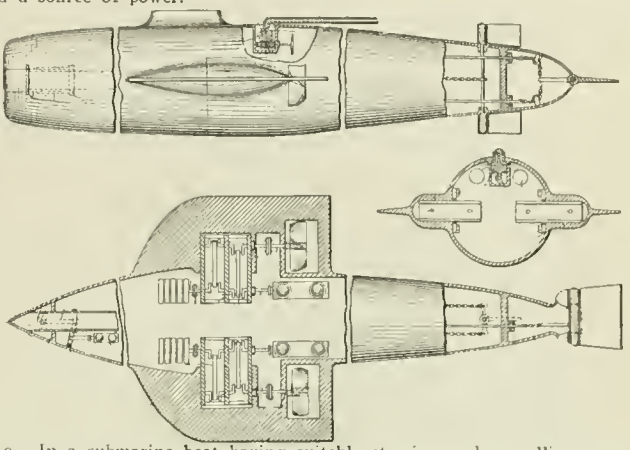
Claim.—In a boat of the character described, the combination with two hulls, each formed independent of the other and of air-tight construction, of a deck connecting said hulls together and holding the same spaced apart,



curved bars at the bow and stern to form gratings, a superstructure forming a paddle-wheel box on said deck, independently-mounted paddle-wheels arranged in said paddle-box to turn between said hulls, a removable cover arranged over each of said wheels, cranks arranged on the ends of said paddle-wheel shafts, connecting-rods connecting said cranks together, engines arranged on said deck, links to connect the piston-rods of said engines to said connecting-rods whereby said paddle-wheels are simultaneously driven, and boilers arranged on said deck to supply steam to said engines. One claim.

803,885. SUBMARINE BOAT. HALVOR O. EIANE, OF THE UNITED STATES NAVY.

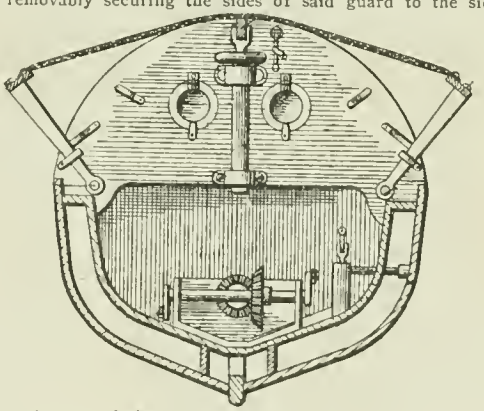
Claim.—1. In a submarine boat or vessel, the combination of a hull, laterally-disposed hydroplanes beneath the surface of the water, propellers arranged at the sides of the vessel, said hydroplanes being chambered and removable crank cases in the chambers of said hydroplanes and accessible from inside the hull, connections between said crank cases, the propellers and a source of power.



10. In a submarine boat having suitable steering and propelling means, a torpedo tube opening at the prow of the vessel, a closure for said tube, said closure comprising two hinged jaws co-operating to fold over the end of the tube, said jaws having slotted crossed rearward extensions, and means for operating said extensions from the interior of the vessel to open and close the jaws simultaneously. Ten claims.

804,095. LIFE-BOAT. FREEMAN W. BROWN, TACOMA, WASH.

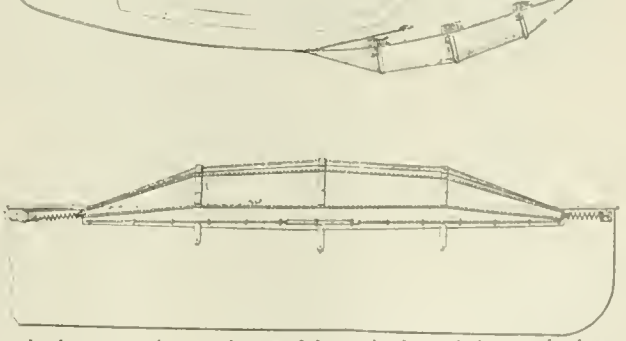
Claim.—1. A boat having a water-guard mounted centrally over its top, means for removably securing the sides of said guard to the sides of the



boat to close the top of the latter, and means for supporting the sides of said guard above the sides of the boat to cause said guard to serve as an awning. Twelve claims.

804,155. SPRAY AND WATER-GUARD FOR BOATS. HARRY C. MORSE, PENN YAN, N. Y.

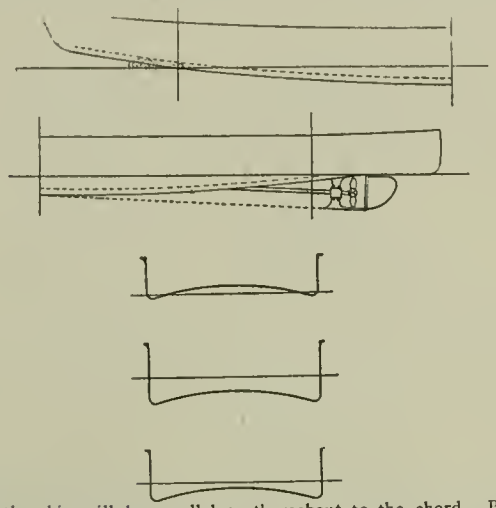
Claim.—1. In a guard of the class described, the combination with a spray-arresting wing having intermediate transverse stretching means and end portions that are of the same length and equally tapered in order to permit either end being placed foremost, of means for attaching the wing



along its inner margin to a boat and in projecting relation to the bow of said boat, and means for securing the tapered ends under tension to the boat. Thirty-seven claims.

804,269. CONSTRUCTION OF THE HULLS OF SHIPS AND BOATS. HERBERT E. ROSS, SYDNEY, NEW SOUTH WALES.

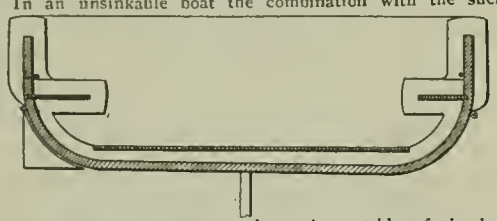
Abstract. The special object of the present invention is to provide such a construction of hull that the vessel shall have a tendency to skim or glide, as nearly as possible, over the surface of the water. To this end the plan of the hull will be an oblong or parallelogram in contour, with vertical or approximately vertical sides depending from the long edges of the parallelogram. The bottom edges of the sides and the external bottom will each form a convex curve, deepest at the center and tapering to zero at both ends, or, briefly stated, each will be a segment of a circle of which the



deck of the ship will be parallel or thereabout to the chord. Between the segmental sides the external bottom will be transversely concaved. The stern may be made flat, so as to lie on the surface of the water, a construction which is at present in use. When screw propulsion is employed, the propeller-shaft may be inclosed and the stern-clearance be of solid deadwood or the shaft may be left bare. One claim.

804,797. DEVICE FOR RENDERING SMALL BOATS UNSINKABLE. JOSEPH M. A. DEYDIER, NYONS, FRANCE.

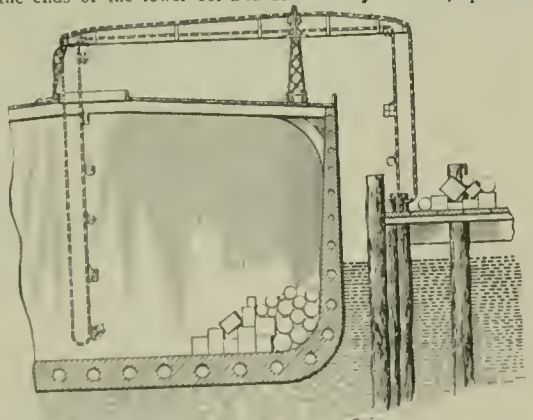
Claim. In an unsinkable boat the combination with the shell of rods



composed of several lengths arranged on the outside of the boat, stuffed waterproof cushions provided with rings intended to be engaged by the said outer rods, means for securing said cushions to the inside of the boat after they have been bent over the edges of the boat-shell, cushions secured to all parts of the inside of the boat and a waterproof covering protecting the cushions placed at the bottom. One claim.

805,711. APPARATUS FOR LOADING AND UNLOADING SHIPS. FRANKLIN B. CLARK, WASHINGTON, D. C., ASSIGNOR TO THE AMERICAN LOADING AND UNLOADING MACHINE CO., (INC.,) OF VIRGINIA.

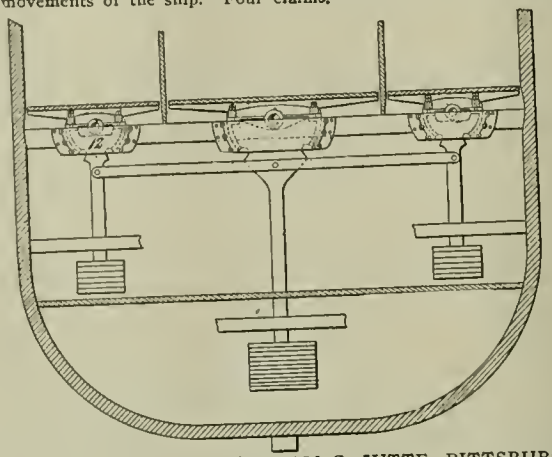
Claim.—2. A loading and unloading apparatus comprising a standard, a truss frame made up of an upper and lower set of tracks connected together and mounted upon said standards, the upper set of said tracks extending beyond the ends of the lower set and downwardly inclined, sprocket wheels



mounted in suitable bearings at the ends of said tracks, an endless carrier mounted to travel upon said tracks and over said sprocket wheels, and a support for corresponding ends of said tracks and through which support said carrier is adapted to travel. Eight claims.

805,718. BALANCED FLOOR FOR SHIPS' CABINS. ROBERT P. DEWEY, SAN FRANCISCO, CAL.

Claim.—1. In a ship, the combination of a movable floor or deck section, a shaft to which the floor section is fixed, a weighted pendulum detached from the floor so as to be independent thereof, and a cross-head or bearing on the shaft and extending beyond opposite sides thereof, said pendulum engaging the cross-head to effect the oscillation of the shaft and floor section and thereby maintain the floor section in horizontal position irrespective of the movements of the ship. Four claims.



805,468. STEEL BARGE. WILLIAM C. JUTTE, PITTSBURG, PA.

Claim.—11. In a barge or other boat, the combination of a side top member comprising an angle-shaped beam having an inwardly-projecting flange at its top edge and having the lower portion of its web offset inwardly, a corner member having the end portions of its top and outer faces offset inwardly to receive the end of said side top member and having the lower edge of its outer face offset inwardly on a line with the inwardly-offset portions of the side top member, and plates riveted to the offset portions of the side top member and at the lower edge of the corner member. Twenty-five claims.

805,496. BUOYANCY-REGULATING APPARATUS FOR SUBMARINE BOATS. LAWRENCE Y. SPEAR, GREENPORT, N. Y., ASSIGNOR TO ELECTRIC BOAT COMPANY, NEW YORK.

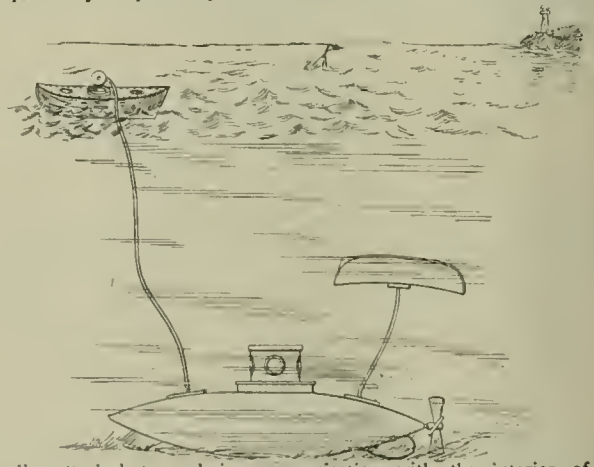
Claim.—1. A submarine boat having means for regulating its buoyancy, comprising a ballast tank, a strong intermediate tank of relatively small capacity, a valve-controlled pipe connecting said tanks, a valve-controlled pipe connecting the stronger intermediate tank with the sea, and means for forcing water from the ballast tank to said intermediate tank and from said intermediate tank to the sea. Four claims.

805,950. GOVERNOR FOR MARINE ENGINES. RODOLPHE J. W. GRASSET, SOUTH YARRA, VICTORIA, AUSTRALIA.

Claim.—2. In an electrically-controlled hydropneumatic governor for marine engines, the combination with the steam valve thereof, of a solenoid having its cores connected directly with said valve and means for energizing the solenoid, said means consisting of an air chamber in communication with the sea, a diaphragm in the upper part of said chamber, a sliding rod connected with said diaphragm, a spring controlling the upward movement of said diaphragm, means for regulating the pressure of said spring, contacts carried by said rod, stationary contacts with which the before-mentioned contacts are adapted to engage and wires connecting the stationary contacts with the solenoid. Two claims.

805,975. LIFE-SAVING BOAT. JESSE A. MARLEY, NEW YORK.

Abstract.—This invention relates to life-boats designed especially for use in connection with submarine vessels, and has for its objects to produce a comparatively simple inexpensive device of this character which will be



normally attached to and in communication with the interior of the vessel, and one whereby in the event of the vessel failing to rise after being submerged persons thereon may escape from the vessel and be saved through the medium of the life-boat. Three claims.

On page 25 of the January issue are a number of equations for determining the mean effective pressure in a cylinder under various conditions. One of our readers has pointed out to us that there is an error in the placing of the decimal point in two of those equations, they being respectively the second equation in the first column and the first equation in the second column of that page. In these two cases, the figures given in the numerators of the fractions within the parentheses should be 2.379 and 2.639, instead of .2379 and .2639, respectively.

Marine Engineering

MARCH, 1906

TRIAL PERFORMANCE OF UNITED STATES BATTLESHIP VIRGINIA.

By A. F. Bowen and H. B. Gregory.

General Description.

The *Virginia** is a twin screw, armored battleship, built by the Newport News Shipbuilding and Dry Dock Company. The contract was signed February 15, 1901, keel laid May 21, 1902, and the ship launched April 5, 1904. The launching weight was 5,983 tons, including 317 tons for cradle and shoring. The contract price was $3,590,000, of which $2,350,000 was allotted for the hull, and $1,240,000 for machinery. Armor, ordnance, anchors, chains, etc., supplied by the government, are not included in the above price. The contract time for the completion was thirty-six months, expiring February 15, 1904. This time was extended to December 27, 1905. The contract called for a speed of 19 knots on a mean draft of 23 feet 9 inches, and was to be maintained for four consecutive hours; the maximum air pressure finally allowed being 2¼ inches, and the average air pressure not to exceed 2 inches. The complement will be 49 officers and 772 men, making a total of 821 men in the crew.

*For description of this ship, with inboard profile, deck plans, several transverse sections, engine drawings and photographs showing her launching, see page 249, Marine Engineering, June, 1904.

THE BATTLESHIP VIRGINIA ON TRIAL TRIP.
(Copyright, 1905, N. L. Stebbins, Boston.)

Hull Dimensions.

Length between perpendiculars (also L. W. L.)	435 ft. 0 in.
" over all	441 ft. 3 in.
Beam molded	76 ft. 0½ in.
" extreme	76 ft. 2½ in.
Ratio of length to beam	5.70
Depth (molded)	41 ft. 3⅝ in.
Draught, normal, mean	23 ft. 9 in.
Displacement (mean load draft 23 ft. 9 in)	14,980 tons
Immersion per inch at L. W. L.	61.10 tons
Area of immersed midship section	1,734 sq. ft.
" " L. W. L.	25,640 sq. ft.
Wetted surface	39,150 sq. ft.

Center of gravity L. W. L. plane aft of M. S.	3.30 ft.
" " buoyancy above bottom of keel	13.0 ft.
" " buoyancy forward of M. S. (frame 54½)	0.11 ft.
Transverse metacenter above center of buoyancy	19 ft. 2½ in.
Longitudinal metacenter above center of buoyancy	519 ft. 0 in.
Coefficient of fineness, block	.686
" " " M. S.	.96
" " " L. W. L.	.775
Cylindrical (prismatic) coefficient	.7149
Number of frames	108
" " watertight compartments	324

ARMOR.

The armor consists of a side belt of Harveyized nickel steel, extending 2 feet 9⅝ inches above, and 5 feet 2⅞ inches below the 23-foot 9-inch load line. The thickness amidships is 11 inches at the top, and 8 inches at the armor shelf, tapering to 4 inches forward and aft. Above the armor belt is the lower casemate, of 6 inches; the upper casemate of 6 inches. The conning tower is 9 inches, and the signal tower 5 inches thick.

There are two elliptical superimposed 8 and 12-inch balanced turrets, forward and aft, revolving over circular barbettes. The turret armor is 12 inches on the face, and 6 and 8 inches thick on the vertical. The barbette armor for these turrets is 10 and 7½ inches thick. There are also two 8-inch elliptical broadside turrets, the front plates of which are 6½ inches thick, with the vertical sides 6 inches. The protective deck consists of two 30-pound plates, with an additional 60-pound plate on the slopes

VENTILATION.

Fourteen systems are used for ventilating the ship, the majority of which supply air (plenum system) to the various compartments. Approximately 95,500 cubic feet of air is supplied per minute, and 6,990 cubic feet exhausted.

BATTERY.

The battery consists of the following principal guns: Four 12 and eight 8-inch breech-loading rifles, twelve 6-inch and twelve 3-inch rapid fire guns.

The torpedo plant is made up of four 21-inch submerged torpedoes, two forward and two aft, with corresponding compressors, accumulators, separators, etc.

EQUIPMENT.

There is a vertical Hyde steam anchor windlass on the main deck forward, the engine being located on the gun deck outside of the windlass house.

The steering engine is of the Williamson Bros. combined hand and steam type. The engine is controlled from the flying bridge, conning-tower and communicating room, by a wire rope actuating the engine-valve.

In the electric plant are six 50-kilowatt and two 100-kilowatt generating sets, all worked at a pressure of 150 pounds, and built by the Thresher Electric Company. The lighting output supplies approximately 1,134 incandescent 16-candle power lamps, 1,692 incandescent 5-candle power lamps for use in the battery control instruments, 6 arc lamps in the fire rooms, and 4 in the engine rooms. The dynamo engines are vertical cross compound. The 50-kilowatt engines have cylinders 8 and 16 inches in diameter, with a stroke of 8 inches. The 100-kilowatt engines have cylinders 10 and 20 inches in diameter, with a stroke of 10 inches. There are also six 30-inch search lights, two sets of night signalling apparatus, and various other electrical machinery.

The following boats will be carried, the handling of which will be done by four electrically operated cranes and boat davits: One 40-foot steam cutter, one 36-foot steam cutter, two 36-foot launches, four 30-foot cutters, two 20-foot dinghys, one 16-foot dinghy, or eleven in all.

PROPELLING MACHINERY.

There are two main engines of the four cylinder, vertical, inverted, direct-acting, triple expansion type, placed abreast in separate watertight compartments with a watertight door between.

The order of the cylinders is: Forward L. P., H. P., I. P. and after L. P. The H. P. and F. L. P. cranks are at 180 degrees, and the I. P. and A. L. P. cranks are at the same angle. The sequence of cranks is: H. P., I. P., F. L. P. and A. L. P. The engines are right and left, and turn the propellers inboard when going ahead. The designed power of the main engines is 19,000 indicated horsepower at about 120 revolutions per minute, wth a steam pressure of 250 pounds at the high-pressure valve chest.

The main engine cylinders consist of a cast iron casing embodying valve chests, steam ports and passages. All cylinders and valve chests are fitted with liners. The cylinder liners are secured to the cylinder casings at the bottom by countersunk screws. At the top there is a composition gland fitted for packing between the liner and the casing, and which allows for expansion, while making a tight joint. The space between the liner and the casing forms the steam jacket for the barrel of the cylinder. The cylinder covers are also jacketed. The valve chest liners are each in two parts—the upper and lower. They are forced into place and secured by screws tapped half into the liners, and half into the casings. The cylinder covers are of cast iron, strongly ribbed and fitted with central manhole. The valve chest covers are of cast iron, well ribbed, the upper covers embodying the balance piston cylinders, and the lower covers bored to receive the valve stem stuffing boxes.

The cylinders are supported on twelve forged nickel steel cylindrical columns, flanged top and bottom, for securing to cylinders and bed-plate, and having enlarged facings for the athwartship and longitudinal tie rods, braces and reverse shaft bearings. The columns are tied fore and aft by heavy cast steel I braces and forged steel diagonal rods, and strengthened athwartships by forged steel X frames with horizontal tie rods at the center. Additional stiffness is given the engines by athwartship tie rods between the cylinders, and fore and aft tie rods between the cylinders to special stiffeners on the forward and after engine room bulkheads.

The bedplates, of cast steel, are in three sections, each consisting of two longitudinal and two cross girders of I section, flanged for bolting together, and each section carrying two main bearings. They are secured to keelson plates provided in the hull structure.

All the main steam valves are of the single-ported piston type, with single cast iron packing rings and cast steel followers for the H. P., with forged steel for the I. P. and L. P. The H. P. valves are of cast iron; the I. P. and L. P. valves are built up with two heads of cast iron and a steel tube distance piece between. The H. P. cylinder has one valve; the I. P. and each L. P. cylinder two each. Each valve is provided with a balance piston fitted at the top of the valve stems, and working in a small cylinder in the valve chest covers, so designed as to relieve a part of the weight of the valve gear. The latter is of the Stephenson type with double-bar forged steel links; the H. P. valve stem being connected directly to its link block, while the two valve stems of each I. P. and L. P. cylinder are connected by a crosshead. The link blocks are of cast steel fitted with brass gibs. Each engine is handled by a steam reversing engine with oil controlling cylinder. They connect direct to arms on the reversing shaft, carried in bearings secured to the front of the engine columns, and provided with an arm for each link, fitted with adjustable cut-off block.

A 12 inch balance throttle valve is fitted to each engine, the balance being accomplished by a piston working in a cylinder cast in valve casing. The valve is controlled by a large handwheel at the working platform.

The pistons are conical in shape, the H. P. being of cast iron

and the I. P. and L. P. of cast steel. All the pistons are fitted with forged steel followers, secured to the piston bodies by studs and nuts having square shoulders, where they pass through the followers to prevent turning. The H. P. and the I. P. pistons are fitted with one solid packing ring set out by steel springs. The L. P. piston packing consists in two rings of seven sections each, set out by steel springs.

The piston rods are hollow, of high grade nickel steel, oil-tempered and annealed. They are accurately ground cylindrical and polished, tapered at each end to fit the piston and crosshead. The crosshead is of nickel steel, forged with the crosshead pins, and is bolted to the cast steel slipper, which is lined with white metal on the sliding faces.

The go-ahead crosshead guides are of cast iron, hollow for water circulation, and are bolted to lugs on the cylinders at the top, and to the cast steel I brace of the engine framing at the bottom. The backing guides are of cast steel, and are bolted to flanges on the ahead guides.

The connecting rods are of the same material as the piston rods with axial hole, and are forked at the upper end to carry the crosshead brasses. To the lower end are secured the crank-pin brasses.

The eccentrics are in two parts, secured together by two screw tap bolts, the larger part of cast iron and the smaller of wrought steel. The backing eccentrics are securely keyed to the crank shaft, and the go-ahead eccentrics secured to them by a bolt fitted in an elliptical hole to allow for adjusting same. The eccentric straps are of composition, lined with white metal. To the upper part of the straps are secured the eccentric rods, which are of nickel steel. The upper ends of the rods are forked to span the main links at the link pins, adjustable brasses being fitted for these pins.

All shafting is of hollow forged nickel steel. The crank and line shafts are each in two sections, and the thrust, stern tube and propeller shafts are one section each, for each main engine. A worm wheel for turning the main engines, and operated by a turning engine, is fitted over the coupling flanges between the two sections of the crank shaft, one for each engine. There are six main bearings for each complete crank shaft, two steady bearings for each thrust shaft, one spring bearing for each line shaft, two stern tube bearings for each stern tube shaft, and one strut bearing for each propeller shaft. At the forward end of each stern tube is fitted a stuffing box and gland for making a watertight joint with the shafting. Wherever the shafting pierces a watertight bulkhead, a shallow stuffing box is fitted to preserve watertightness.

All shaft couplings are of the flange type forged to the shafts, except for the inboard coupling of the stern tube shaft and the outboard coupling securing stern tube and propeller shafts. The former consists of a forged steel collar secured on the end of the shaft by four steel keys; behind this collar is another collar in halves, and fitting snugly around the shaft behind the shoulders of the collar seating, both collars being bolted to the after flange of the line shaft. The outboard coupling consists of a forged steel sleeve, taper bored from ends to center for the reception of tapered shaft ends. It is secured from turning by two steel keys at each end, and the shafts are secured against withdrawal by tapered cotters driven through slots in sleeve and shaft ends, the grooves around cotter slots being filled with solder, and screw stop pins let in to secure the cotters. The sleeve couplings are covered by a cast composition casing, the space between the casing and couplings being filled with tallow and resin melted together.

THE UNITED STATES BATTLESHIP VIRGINIA.
(Upper 8-inch Turrets not yet fitted.)

The thrust bearings, one for each engine, are of the ordinary horseshoe type, consisting of a cast iron pedestal bolted down on a cast iron sole plate. The latter is securely fastened by rivets to the foundation built up from the hull structure. The lower part of the pedestal forms an oil trough in which the lower part of the collar seating, both collars being through bolted to the circulating coil for cooling the oil. A steady bearing is at either end of the pedestal. There are twelve horseshoes of cast steel, made hollow for the circulation of water, and lined with white metal on both sides, except that the forward one is lined only on the after side, as it is only for forward thrust, and bears on the forward side of the forward collar. Each horseshoe is independently adjusted fore and aft by steel screwed side rods and wrought iron clamp nuts.

ENGINE DATA.

Cylinders, H. P., diameter, inches	35
I. P., diameter, inches	57
L. P. (2), diameter, inches	66
Stroke of all pistons, inches	48
Piston valves, H. P. (1 each cylinder), diameter, inches	20
I. P. (2 each cylinder), diameter, inches	22
L. P. (2 each cylinder), diameter, inches	25

Number of Run	Which Engine	Steam Pressures Pounds Per Square Inch: Boilers (Gauge)	At Eng. (Gauge)	H. P. Steam Chest (Absolute)	1st Rec. (Absolute)	2d Rec. (Absolute)	Mean Effective Pressures Pounds Per Square Inch: H. P. Cyl.	I. P. Cyl.	F. L. P. Cyl.	A. L. P. Cyl.	Referred to L. P. Cyls.	Vacuum in Inches	Air Press. in Fire Room in Inches of Water
1-S	S	262	250	255	105	35	109.7	46.5	15.9	18	49.38	27	.92
	P		245	255	100	34	107	49	16.2	17.6	49.89	27.2	
2-N	S	268	255	260	105	35	121	47	16.1	19	51.72	27.3	1.21
	P		250	260	102	36.5	106.5	51.5	18	18	52.29	27	
3-S	S	263	245	255	105	36	110	48	16.5	18.4	50.47	27.2	.93
	P		240	250	110	37	92	57	18.2	17 5	51.74	27	
4-N	S	263	245	255	120	40	101.5	56.5	18	20	54.02	27.3	1.27
	P		245	255	103	36.8	101.5	52	18.1	17.5	51.13	26.6	
5-S	S	264	250	255	115	38	99.5	56.5	18.2	20.2	53.94	27.4	1.11
	P		245	255	117	36	99.5	53.5	17.6	18.6	51.72	27.2	
6-N	S	266	250	260	90	32	126.5	40.5	12.7	14.1	45.92	26.1	1.11
	P		245	255	99	31	120	45.5	13.5	14.5	47.47	27 4	
7-S	S	259	245	235	81	28	119	38.3	13.2	15.8	45.16	28.3	.47
	P		245	241	84	26	110	39	11.2	13.3	41.93	27.5	
8-N	S	260	247	215	70	24	109	32.5	11	13.6	39.42	28.5	.49
	P		247	205	78	24	104	36	12.9	12.2	40.28	28	
9-S	S	257	250	205	65	20	92	31	9.2	12.7	35.17	28	.18
	P		252	190	70	21	98.5	33.1	12.3	10.8	37.94	28.5	
10-N	S	244	225	190	62	19	98.5	29.1	8.8	11.8	34.71	27.2	.19
	P		226	175	64	19.5	94	29.2	9.8	9 9	33.67	28.3	
11-S	S	253	240	180	57	20	93	26.8	9	10.1	32.35	28	.15
	P		242	168	61	19.2	89	29	9.5	9.4	32.25	27.7	
12-N	S	248	238	165	52	18.5	86	35	8.3	9	33.53	28	.32
	P		237	162	58	17.2	84	27.1	8.3	8.4	30 01	27.6	

Main steam pipe, diameter at throttle, inches..... 12
Net area of I. P. to H. P. piston, ratio.....2.652 to 1
L. P. pistons (2) to H. P. piston, ratio...7.112 to 1
Piston rods, diameter, inches 8
axial hole, H. P. and I. P., inches.. 4
L. P., inches.. 5
length, feet and inches..... 9— 4⅛
Connecting rod, length center to center, inches..... 96
diameter upper end, inches..... 7¾
diameter lower end, inches..... 9
diameter axial hole, inches..... 5
Crank shafts, diameter, inches 17½
diameter axial hole, inches..... 10¼
diameter coupling disc, inches..... 32
thickness coupling disc, inches..... 3¾
coupling bolts (8 each flange), diameter, inches 3½
length forward section H. P. and F. L. P., feet and inches.....15— 6¼
length after section, I. P. and A. L. P., feet and inches.....16—10
Crank pin, diameter, inches 18
length, inches 21½
axial hole, diameter, inches..... 10½
Crank webs, width, inches 20
thickness, inches 11
Thrust shaft, diameter, inches 16½
axial hole, inches..... 10¼
length, feet and inches.....13— 7½
collars, number on each shaft..... 12
diameter, inches 27
thickness, inches 2
space between, inches..... 4
Line shafts, diameter, inches 16½
axial hole, inches..... 10¼
length forward section, feet and inches....14—11½
after section, feet and inches.....14—11
Stern tube shaft, diameter, inches 17½
diameter axial hole, inches..... 10¼
length, feet and inches.....36— 0
Propeller shaft, diameter, inches 17½
diameter axial hole, inches..... 10¼
length, feet and inches.....25— 8¼
Reversing engine, diameter steam cylinder, inches..... 16
diameter oil cylinder, inches..... 8
stroke, inches 22
Turning engine, diameter steam cylinders (2), inches..... 7
stroke, inches 5

AUXILIARY MACHINERY.

Main Condensers.—There is one main condenser for each main engine. They are cylindrical in form, with steel shell and composition water heads.

Diameter of shell (inside)..... 7 feet 0 inches
Length over all.....15 feet 5 inches
Tubes, diameter (outside) ..... ⅝ inch
length between tube sheets.....12 feet 10 inches
thickness, No. 18 B. W. G..... .049 inch
number in each condenser..... 5,684
Cooling surface, square feet, each..... 11,969

Main Air Pumps.—There are two main air pumps, one in each engine room, of the Blake, twin cylinder, vertical, beam, single acting type.

Diameter steam cylinders (2).....14 inches
Diameter pump cylinders (2).....32 inches
Stroke .....21 inches

Main Circulating Pumps.—One centrifugal, double-inlet, circulating pump driven by a compound engine is provided for each main condenser. Each pump has a capacity of 12,000 gallons of water per minute at about 266 revolutions. Each pump is arranged to draw from the sea, the main drain and the engine room bilge, and discharges through the condenser, or directly overboard, through the by-pass in the inlet and outlet condenser head, to the overboard delivery. The suction valves to these pumps are so interlocked that the sea valve and the bilge and drain valve cannot be opened at the same time.

Diameter of steam cylinders...H. P. 11 inches, L. P. 22 inches
Stroke .....10 inches
Diameter of pump runner.....45 inches
" " inlet nozzles (2).....15½ inches
" " outlet " .....20 inches

Number of Run	Time on Course Min.-Sec.	Which Engine	Revolutions Main Engines			Speed in Knots	Indicated Horsepower						Total Aux. in Operation During Test	Total All Machinery
							Main Engines							
			To Make One Knot	Per Min.	Mean Per Min.		H. P. Cyl.	I. P. Cyl.	F. L. P. Cyl.	A. L. P. Cyl.	Total	Total Both Engs.		
1-S	3-2.5	S	390.6	128.45	128.26	19.731	3200	3658.5	1681.5	1903.5	10443.5	20963.5	704.2	21797.3
		P	389.45	128.07			3112	3844	1708	1856	10520			
2-N	3-18.4	S	424.30	128.38	128.47	18.152	3527.8	3695.8	1701.7	2008.2	10933.5	21909.3	709.0	22727.6
		P	424.95	128.57			3109.6	4055.6	1905.3	1905.3	10975.8			
3-S	3-2.4	S	393.55	129.49	129.59	19.742	3234.9	3807	1759	1961.6	10762.5	21811.8	720.9	22636.7
		P	394.15	129.69			2908.9	4527.8	1943.3	1868.5	11049.3			
4-N	3-16.6	S	426.20	130.07	129.13	18.311	2998.3	4501.3	1927.5	2141.8	11568.9	22363.9	677.7	23147.2
		P	420.05	128.19			2954.9	4082.9	1910.3	1846.9	10795			
5-S	3-2.8	S	398.40	130.91	130.31	19.694	2958	4530.3	1961.6	2177.1	11627	22674.1	689.9	23459.4
		P	394.75	129.71			2930.9	4250.4	1879.5	1986.3	11047.1			
6-N	3-18.4	S	414.35	125.18	125.20	18.145	3596.2	3105.3	1308.8	1453.1	9463.4	19251.4	564.6	19911.4
		P	414.45	125.21			3412.2	3489.4	1391.6	1484.8	9788			
7-S	3 11.9	S	383.55	119.96	119.58	18.760	3242.0	2814.2	1303.7	1560.5	8920.4	17149.9	387.8	17633.1
		P	381.15	119.20			2977.8	2847.4	1099.1	1305.2	8229.5			
8-N	3 27.8	S	396.90	114.63	114.70	17.329	2844	2281.8	1038.1	1283.5	7447.4	15059.7	358.6	15513.7
		P	397.35	114.76			2710.4	2530.4	1218.8	1152.7	7612.3			
9-S	3-21.6	S	376.95	112.30	112.28	17.857	2346.4	2132.3	850.6	1174.2	6503.5	13424.9	329.7	13849.6
		P	376.80	112.25			2510.9	2275.7	1136.7	998.1	6921.4			
10-N	3-38.1	S	398.45	109.62	109.08	16.506	2452.2	1953.8	794.2	1065	6265.2	12283.8	290.8	12669.1
		P	394.55	108.54			2317.0	1941.2	875.7	884.7	6018.6			
11-S	3-31	S	377.15	107.30	107.12	17.062	2266.2	1761.3	795	892.2	5714.7	11395	288.6	11785
		P	375.85	106.93			2161.2	1899.3	792.3	827.5	5680.3			
12-N	3-47	S	386.00	102.05	102.38	15.863	1947.7	2187.7	697.4	756.1	5588.9	10664.8	294.7	11069.5
		P	388.45	102.70			1859.2	1704.7	701.8	710.2	5075.9			

Feed and Filter Tanks.—There is located in each engine room, under the main condenser, one combined feed and filter tank, of 4,800 gallons capacity. The filter box is built in the upper after end of the tank. It consists of three separate compartments, each filled with the filtering material through which the water from the main and auxiliary air pumps' discharge passes successively before entering the feed tank.

Feed Pumps.—There are four main feed pumps of the Blake simplex, vertical, double-acting, center-packed plunger type, located on the forward bulkheads, two in each engine room. They are arranged to draw water from the feed tanks direct or from the hot well pump discharge, through the feed water heaters, and discharge into the main feed line only. There are six auxiliary feed pumps of the same type as the above, located one in each fire room on the centerline bulkhead. They have suction from the feed tanks, the sea, the boiler blow pipes and the drainage manifold in their own compartment, and discharge into the auxiliary feed line, overboard, and the fire main.

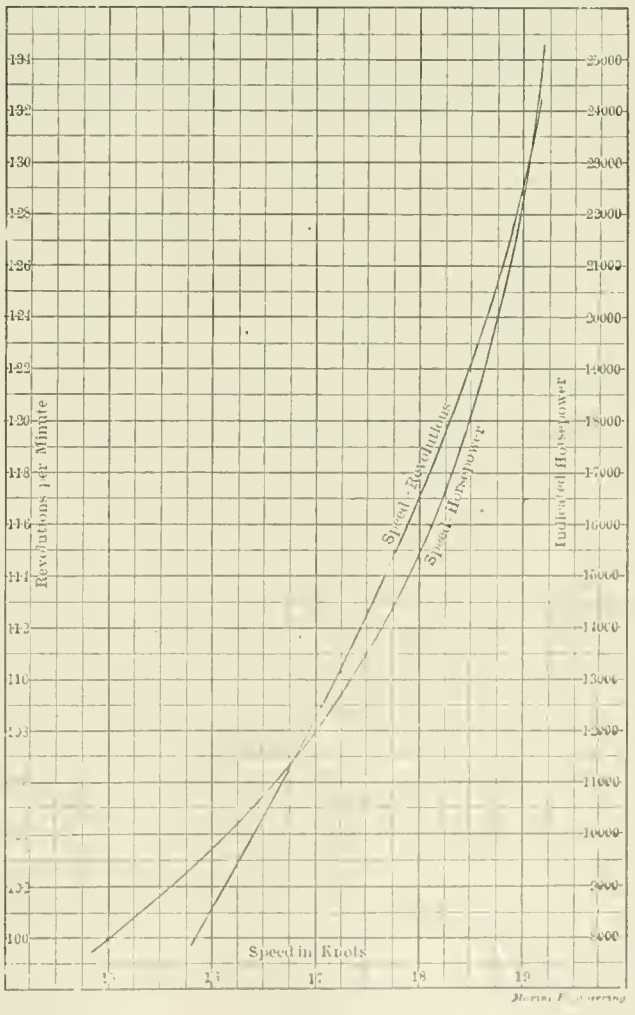
Main feed pumps, diameter of steam cylinder .....14 inches
" " water " .....10 inches
stroke .....12 inches
Auxiliary feed pumps, diameter of steam cylinder.....11 inches
" " water " ..... 8 inches
stroke .....12 inches

Hotwell Pumps.—There is one Blake simplex, vertical, double-acting, hotwell pump in each engine room, having suction connections to the feed tanks, reserve feed tanks in the double bottoms, and the filling pipe from side of ship. These pumps discharge through the feed water heaters to the main feed pumps' suction, to the feed tank, and to the reserve feed tank.

Diameter of steam cylinder .....12 inches
" " water " .....14 inches
Stroke .....12 inches

Distiller Circulating Pump.—There is one distiller circulating pump in the starboard engine room, of the same size and type as the hotwell pumps. This pump has a sea suction and discharges overboard, or to the flushing main through the distillers or direct.

Fire and Bilge Pumps.—There is one fire and bilge pump of the Blake simplex, vertical, double-acting type, located in each engine room. These pumps draw water from the sea, the



SPEED CURVES BASED ON HORSEPOWER AND REVOLUTIONS.

drainage system and from the bilges in their own compartment, and discharge into the fire main or ovrboard.

Diameter of steam cylinder	12 inches
" " water "	10 inches
Stroke	12 inches

Feed Water Heaters.—There is one horizontal feed water heater in each engine room, located high up under the protective deck. The heating agency is exhaust steam from the auxiliary exhaust line which enters the shell at the top, circulates around the tubes and then drains at the bottom. The feed water passes through the tubes. A spring relief valve is provided at the exhaust inlet to adjust the back pressure for properly heating the feed water.

Diameter of shell (inside)	2 feet 11½ inches
Tubes, number	852
diameter, outside	⅝ inch
thickness, No. 16 B. W. G.	.065 inch
length between tube sheets	6 feet 10 inches
length over all	8 feet 8¾ inches
Heating surface, square feet, each	950

Auxiliary Condensers.—There are three auxiliary condensers, one in each engine room, and one in the lower dynamo room on the port side outboard. They are of the Wheeler type, with combined air and circulating pump attached to and under the condenser.

	Engine Room	Dynamo Room
Diameter of shell (inside)	2 feet 4 inches	2 feet 11¼ inches
Length over all	7 feet 10¾ inches	9 feet 1½ inches
Tubes, number	552	1001
diameter, outside	⅝ inch	⅝ inch
thickness, No. 18 B. W. G.	.049 inch	.049 inch
length between tube sheets	6 feet 8 inches	7 feet 4 inches
Cooling surface, square feet, each	601.4	1200.9

Forced Draft Blowers.—There are twelve Sturtevant blowers, situated two in each boiler compartment above the boilers. They deliver air directly into the fire rooms, the closed fire room system being used. Type of blower engines—two cylinder, vertical, double engine.

Steam cylinders, diameter	6 inches
Stroke	5 inches
Fan, diameter	66 inches

Ash Hoists.—For the removal of ashes from the fire rooms, one ventilator in each fire room is fitted with angle guide strips to facilitate the hoisting of buckets through same and thence by trolley to chutes at the ship's side. The hoisting is done by three Williamson Bros., 4½x4½ inches, reversible ash hoist engines, one located at the gun deck level immediately above each pair of athwartship fire rooms.

Distilling Apparatus.—The distilling apparatus is situated on the berth deck just forward of the engine hatch. It consists of four evaporators of the horizontal type, and three vertical distillers located in a trunk above the evaporators. The designed capacity of the plant was 19,000 gallons of water per twenty-four hours, which requirement was most successfully met when tested.

Refrigerating Apparatus.—This plant consists of one three-ton Allen dense air ice machine of the latest design, supplying air to the cold storage rooms, ice-making tank, and scuttle butts. The official test of this plant showed highly satisfactory results.

SCREW PROPELLERS.

The screw propellers are three-bladed, of manganese bronze, and turn inboard when going ahead. They are designed as true screws, and the surfaces of the blades are ground smooth with an emery wheel, and edges filed sharp. The hubs and blades are cast separate, the latter being bolted to the hub by nine tap bolts each; and the bolt holes in the palms of the blades are elliptical to permit of adjusting the pitch. When the pitch has been set, the space between the bolts and edges of the elliptical holes is filled in with fitted composition chocks to prevent the blades from turning and altering the pitch.

Diameter of propeller	17 feet 3 inches
" " hub	4 feet 6 inches
Pitch as set	18 feet 7⅞ inches
Helicoidal area, square feet	84.5
Disk area, square feet	233.71
Pitch ÷ diameter (pitch ratio)	1.078

BOILERS.

There are twenty-four Niclausse boilers arranged in groups of four in six boiler compartments. Each group consists of two pairs of boilers with athwartship fire rooms between pairs. In general the boilers consist of a number of elements, each composed of a vertical header and tubes connected to same. The headers are arranged side by side across the front of the boiler, with the tubes inclined slightly downward, and extending to the rear over the grates. A horizontal drum surmounts the headers to which they connect. The twelve inboard boilers are composed each of sixteen elements, and the twelve outboard boilers of fifteen elements.

Floor space, length, each boiler	8 feet 7 inches
width (15-element boiler)	9 feet 10 inches
width (16-element boiler)	10 feet 5¼ inches
Grates, length	6 feet 8⅝ inches
width (15-element boiler)	8 feet 9 inches
width (16-element boiler)	9 feet 4¼ inches
surface (15-element boiler)	58.78 square feet
surface (16-element boiler)	62.86 square feet
surface (all boilers)	1,459.68 square feet
Heating surface, (15-element boiler)	2,320.07 square feet
(16 element boiler)	2,474.44 square feet
(all boilers)	57,534.12 square feet
Ratio H. S. ÷ G. S.	39.41
Number of generating tubes in one boiler (15-element)	360
Number of generating tubes in one boiler (16-element)	384
Diameter generating tubes	3¼ inches
Thickness generating tubes (No. 6 B. W. G.)	0.203 inch
Diameter circulating tubes	1 19/32 inches
Thickness circulating tubes (No. 21 B. W. G.)	0.032 inch
Diameter steam drum, inside	40½ inches
Working pressure, designed, pounds per square inch	265

STANDARDIZATION TRIAL.

The *Virginia* sailed from Newport News, Va., on Saturday morning, November 18, 1905, and proceeded to Rockland, Me., the place designated for the trials. On the run up the coast, the engines were thoroughly tested by the builders. Rockland was reached Monday morning, November 20, after a most successful trip, and immediately after coming to anchor preparations for the trials began.

The method of trial decided upon was that generally known as the standardization method. It consists of progressive runs over a measured mile, and from the data taken thereon, curves are plotted from which the speed of the vessel may be readily obtained for any number of revolutions of the main engines. The progressive trials were run over the government course at Rockland, on Tuesday, November 21. Twelve progressive runs were made, and the results obtained are shown in Tables I and II. The curves are plotted from this data.

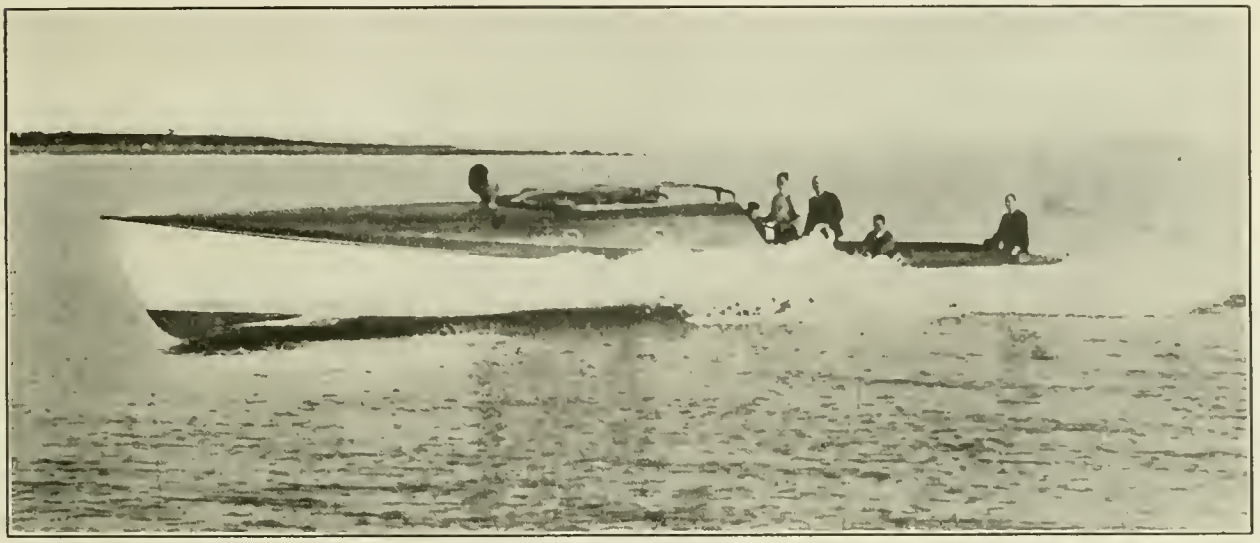
From the data obtained, 129.4 revolutions per minute of the main engines was found to be necessary to make the contract speed of 19 knots.

FOUR HOURS' TRIAL.

This trial took place on Thursday, November 23, at sea, between Rockland and Boston, and an average speed of 19.01 knots was maintained for the four hours.

The following is the data obtained:

	Starb'd		Port.
Steam pressure at boilers (gauge),		260	
engine room (gauge),	240.5		250.8
H. P. steam chest (gauge),	227.4		229.6
1st Receiver (absolute),	114.2		122.
2d Receiver (absolute),	38.8		39.6
Vacuum in condensers, inches of mercury,	27.2		27.
Revolutions per minute:			
main engines (mean trial),	129.6		129.54
average for both,		129.57	
circulating pump,	169.7		167.
blower engines, average,		528	
Double strokes of main air pumps,	19.8		22.3
main feed pump,	26.6		35.7
fire and bilge pump,	68.2		73.6
hotwell pump,	35.8		32.
Speed of ship, in knots,		19.01	
Slip of propellers, in percent of their own speed, based on mean pitch and average speed,	20.07		20.04
Air pressure in fire rooms, inches of water,		1.78	
Mean effective pressures main engines:			
H. P. cylinder,	97.3		82.31
I. P. cylinder,	54.1		58.46
F. L. P. cylinder,	17.7		20.06
A. L. P. cylinder,	19.8		20.01
Mean equivalent pressure in pounds per square inch referred to combined area of L. P. pistons,	52.32		53.15
Indicated horsepower main engines:			
H. P. cylinder,	2,863.8		2,421.5
I. P. cylinder,	4,296.3		4,640.7
F. L. P. cylinder,	1,887.2		2,139.6
A. L. P. cylinder,	2,117.9		2,134.2
Total,	11,165.2		11,336.
Total, both main engines,		22,501.2	
main air pump,	11.75		13.3
main circulating pump,	56		53.
main feed pump,	69.5		102.
fire and bilge pump,	7.8		4.7
hotwell pump,	18.5		15.9
sanitary pump,		6.8	
blower engines,		528	
dynamo engine,		80	
Total, auxiliary machinery,		967.25	
Total, all machinery in operation during trial,		23,468.45	
Coal, kind and quality,		New River, hand picked	
pounds per hour,		68,507	
pounds per square foot of G. S.,		46.932	
pounds per square foot of H. S.,		1.191	
pounds per I. H. P. per hour of all machinery in operation during trial,		2.877	
I. H. P. (total) per square foot of G. S.,		16.078	
I. H. P. (total) per square foot of H. S.,		.408	



VERITAS AT FULL SPEED ON THE HUDSON RIVER.

PROBLEMS IN CONNECTION WITH HIGH SPEED LAUNCHES.*

BY CLINTON H. CRANE.

The very recent development of the so-called "gasoline engine," of extremely light weight in proportion to its power, has given the opportunity of making another step forward in the direction of great speed upon the water. Up to the present time gasoline engines of extremely light weight have been available only in powers up to 300 horsepower, and in the majority of cases of successful operation, in powers not exceeding 150 horsepower. In utilizing this new form of power up to the present time the size of the boats has necessarily been small. In choosing a type of hull naval architects have had to avail themselves of what had already been done in steam.

A glance at the four torpedo boats illustrated will show the very great differences in the shapes of waterlines, profiles and sections adopted by these four successful designers, to produce an easily-driven hull. Such differences would seem to show that, with a given displacement and power, the shape of the under-water form, provided it be reasonably fair, was not of the greatest moment, or rather, that there might be objections to the more easily driven form which made some compromise advisable.

This statement must be modified, as I do not wish to be understood that the services of a skilled naval architect are unnecessary in the building of the fastest possible launch. The saving of weight to the last ounce is a matter of great engineering skill. The choice of a proper propeller, the adaptation of a form which can maintain its speed in rough as well as smooth water

*Read at the thirteenth general meeting of the Society of Naval Architects and Marine Engineers, November 17, 1905.

—all these are matters calling for the greatest possible training, experience and attention.

The simile of the skipping stone has been used by a number of engineers in describing the action of these light, high-speed vessels. The idea that a boat should skim over the top of the water and not go through it is by no means a new one. Over thirty years ago a clergyman, the Rev. C. Ramus, was so firmly convinced that all vessels should proceed in this manner that

TREFLE Á QUATRE IN THE RACES AT MONACO.

ne succeeded in prevailing on the English Admiralty to give his ideas a trial in the experimental tank at Torquay. The result of these trials seemed to show the absolute fallacy of the reverend gentleman's ideas; but the experiments were based on what was then possible in the direction of displacement and power, and with what then seemed a most liberal prediction of future possibilities. We can only feel that Mr. Ramus lived too early.

Two years ago Mr. Yarrow conducted a number of experiments with full size models in a 40-ft. launch towed by one of his 25-knot torpedo boats. The model which gave the least resistance at this speed was a flat bottomed scow, which appeared to glide along the surface of the water. Based on this experiment the *Napier II* was designed with such modification of bow as seemed essential for a boat which would be called upon to perform in a seaway. The final successful trial of this boat was made in March of 1904, on the Thames, at Greenwich, and a speed of practically 26 knots was attained. The boat was driven by two four-cylinder Napier engines, and the displacement on trial was 3 tons 4 cwt.

This gives us a very interesting comparison with the *Dixie,* which was driven by a single engine of 8 cylinders of the same diameter and slightly greater stroke. It may be reasonably assumed that the powers developed in the two boats are practically the same. The speed attained by the *Dixie* was practically the same, although her displacement is nearly 2,000 pounds less than that of the Yarrow boat.

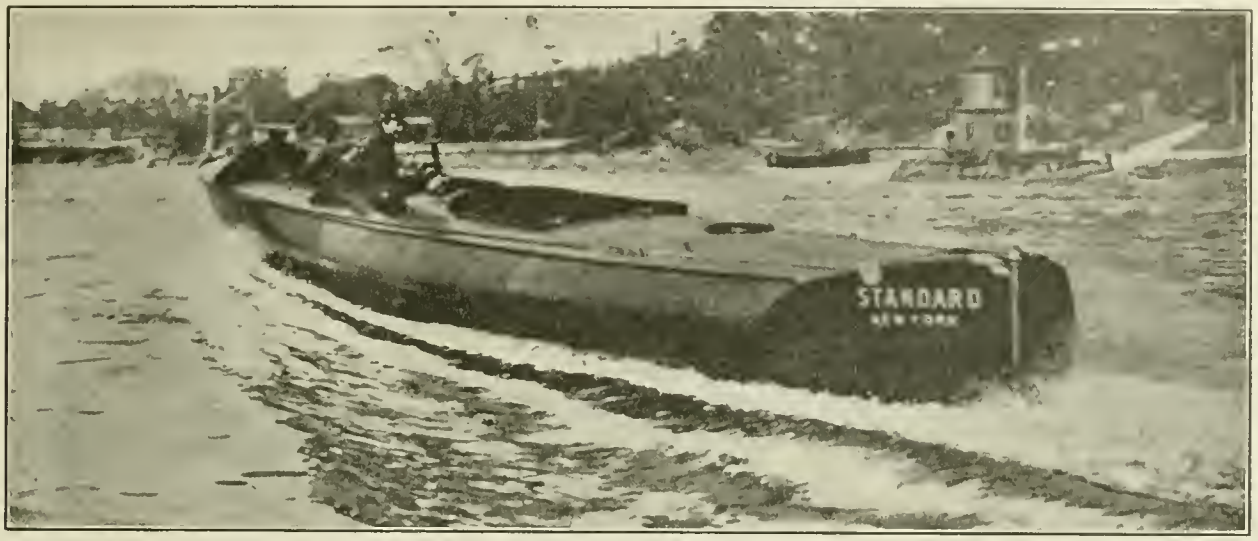
This seems to confirm Mr. Yarrow's conclusion that in boats of this size and going at this speed the skimming idea gives the lesser resistance. It is, however, associated with the form of hull, which is very badly adapted to maintaining high speed in a seaway. As a matter of fact, in spite of her extra weight of hull, *Napier II* was obliged to withdraw from a number of her races, owing to leaks caused by the pounding of her flat bottom on the waves.

I think no one will question the fact that sharp ends and sharp floors go through a sea with far less shock and trouble than extremely full ends and flat floors. It is not so much that the flat floors stop a boat's progress as that they put a shock and jar on the whole fabric, which necessitates heavier construction and does away with the possible advantages gained by this particular form of hull.

XPDNC OPPOSITE THE WEEHAWKEN PALISADES.

The most serious objection to sharp bows and "tooth-pick" sterns, as they used to be called, is the loss of stability which this form involves. Apparently this loss of stability is much more

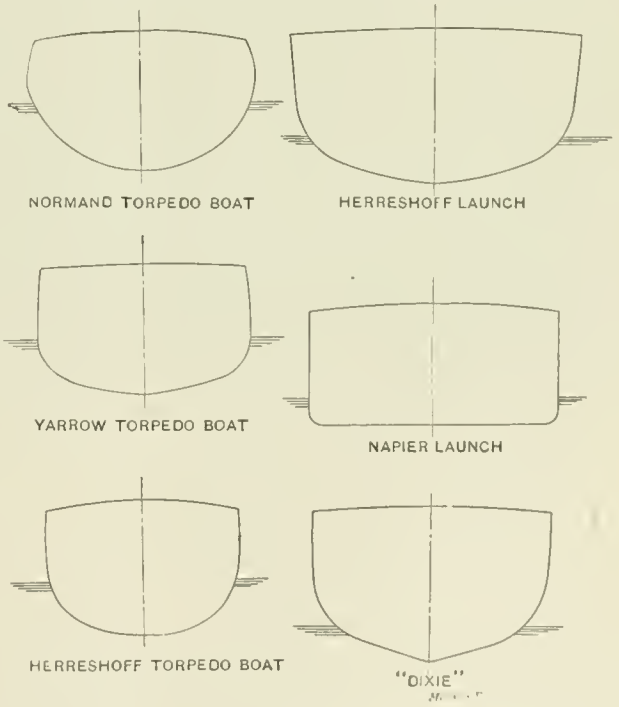
serious and more noticeable at high speeds than at low. Whether this is entirely due to the increased torque of the propeller, is a matter about which the writer is not yet entirely clear. This torque of the propeller in a fast single screw launch is a matter of serious consequence. In the case of the *Dixie*, running at full power, this torque amounts to placing a weight of 350 pounds at the gunwale, or about 8 percent of the boat's weight. This can, of course, be partially compensated for by placing the machinery off the center.



STANDARD RUNNING AT HIGH SPEED.

Launches.	Torpedo Boats	Designer.	Length of W. L.	Disp. in Lbs. or Tons in Running Condition with Crew and Fuel on Board.	Horsepower.	Cylinders. Number.	Cylinders. Diameter.	Cylinders. Stroke.	Maker of Engine.	Speed in Knots.	Weight in Lbs. per H. P.	Weight Reduced to 40 Ft. W. L.	Corresponding Speed in Knots 40 Ft. W. L.
XPDNC.....	.....	Herreshoff.	42.2	3,250 lbs.	75	4	6½	5¼	Mercedes.	23	43.4	2,750	22.4
Napier..... (Twin Screw.)	.....	Yarrow	40	7,170 lbs.	150	8	6¼	6	Napier ...	25.98	47.8	7,170	25.98
Dixie.....	.....	Crane.....	40	5,160 lbs.	150	8	6½	6¼	Smith & Mabley.	26	34.4	5 160	26
Veritas.....	.....	Gielow.....	56	12,000 lbs.	283	8	7¾	9	Craig.....	23.2	42.4	4.370	19.6
Panhard....	.....	Electric Launch Co.	39.91	3,621 lbs.	70	4	6⅛	6.68	Panhard..	23	51.7	3.621	23
Vingt-et-Un II	.....	Crane.....	38.75	3,850 lbs.	75	4	6¼	6¼	Smith & Mabley.	22	51.4	4 225	22.35
.....	Normand torpedo boat.	.....	157	168 tons.	3.920	..	..	..	....	29.15	96	6,250	14.7
.....	Yarrow torpedo boat.	.....	152.7	144 tons.	2,000	..	..	..	....	25	161.5	5 800	12.8
.....	Herreshoff torpedo boat.	.....	175.5	165 tons.	3.200	..	..	..	....	28.6	115.5	4.380	13.65
.....	Thornycroft torpedo boat destroyer.	.....	214	420 tons.	8,000	..	..	..	....	29	117.5	4.160	11.75

Unfortunately, however, for the comfort of those on board this torque is by no means a constant quantity. If the boat throws her wheel out of water, even to a small extent, in the hollow of a wave, this torque is suddenly relieved and the recoil in the opposite direction is sudden and disconcerting.



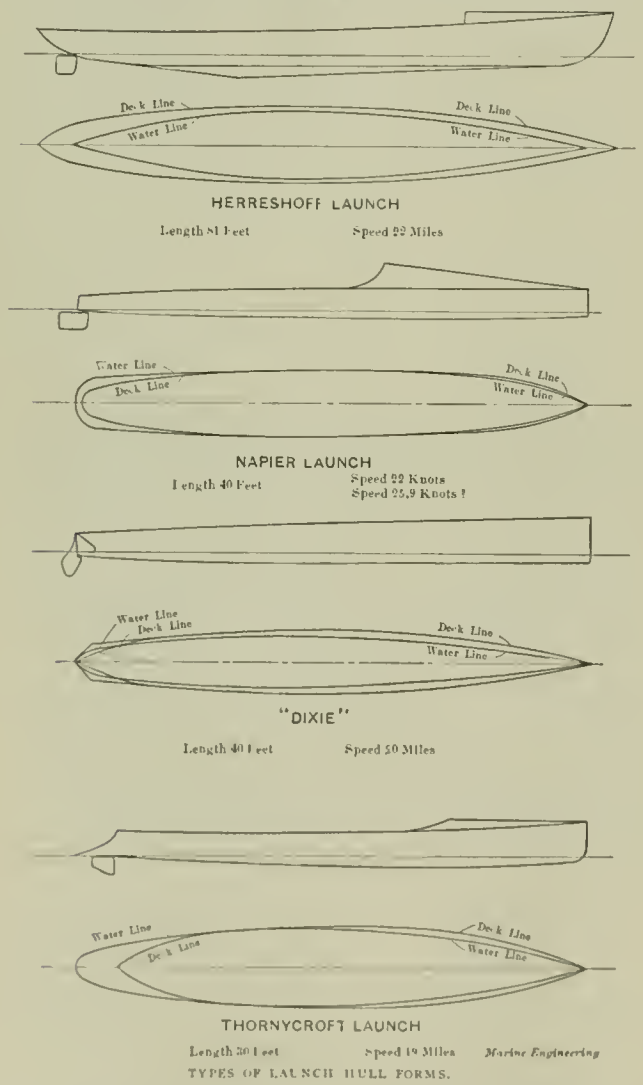
MIDSHIP SECTIONS OF LAUNCHES AND TORPEDO BOATS.

It is possible that this increase in torque may alone account for the trouble which a number of the high speed boats have experienced this summer. In designing the *Dixie* this matter was carefully considered, and she was given practically the same metacentric height as the *Vingt-et-Un II*, *Vingt-et-Un II's* G. M. being .725 and the *Dixie's* G. M. .675. It was expected that the increase in torque could be compensated for by the placing of the crew. In actual result *Dixie* behaves very much as the *Vingt-et-Un* did up to 21 or 22 knots. If driven faster than this in a seaway she becomes very cranky, rolling so deep as to shake the nerve of the uninitiated.

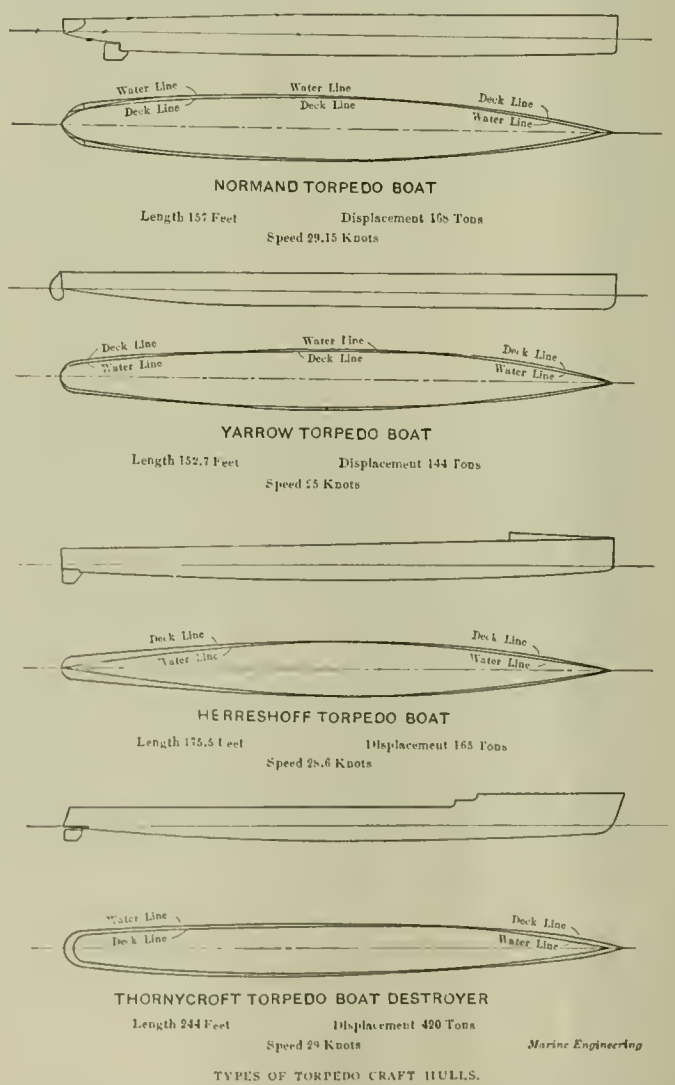
It has been found necessary on all these boats to use a comparatively large size rudder. The uneven thrust of the screw gives a very strong pressure to deviate from the course. Right-handed screws throw the stern to starboard, left-handed to port; this no doubt being partly due to the fact that the bottom of the screw is working in more solid water, and partly to the rather rank inclination of the shaft made necessary by the large power and extremely light displacement, which increases the slip on the descending blade and decreases it on the ascending. This difference of slip is as much as 4 or 5 per cent. That is, if the slip of the descending blade is 25 percent, the slip of the ascending blade would be 20 percent.

DIXIE RACING ON THE HUDSON.

In the *Dixie* we have been using a propeller, to obtain the maximum speed, of 23½ inches diameter, 32 inches pitch, with a surface ratio of 55 percent, this wheel turning 1,120 revolutions. The boat has not been raced with this wheel, as the piston speed is a little excessive for long continued running. This wheel should be perilously near the point of cavitation. As a matter



TYPES OF LAUNCH HULL FORMS.



TYPES OF TORPEDO CRAFT HULLS.

of fact I have encountered cavitation this year on a smaller wheel, running at fewer revolutions in a slower hull.

There is one more point about the shape of the model which is worth consideration. The sharp bowed boats throw a much smaller bow wave than the full bowed ones. This mass of water, although it is usually a thin, transparent film, adds greatly to the discomfort of those on board. The boat driving along at nearly 30 miles an hour against a wind and sea, this water strikes the face as from a fire hydrant.

The table which is given will be of interest. The lengths, weights, speeds and sizes of cylinders I can vouch for as being correct. The horsepowers of the gasoline engines are, with the exception of the *Vingt-et-Un II*, subject to a general calculation, and are based on the sizes of the cylinders and an assumed piston speed. They are certainly accurate within 10 percent. The column $\frac{\text{Weight in Pounds}}{\text{Horsepower}}$ is one of extreme interest. As all these boats were actually weighed by disinterested parties the results can be taken as accurate.

There are, besides the boats enumerated in this column, a number of others which as a matter of general interest should be mentioned; but I was unwilling to publish any figures unless I was certain of their accuracy.

In my opinion, for the best use we need a compromise between the extremely sharp and the extremely flat types. It is in arriving at this compromise that the naval architect can best show his skill.

A Central American Gunboat.

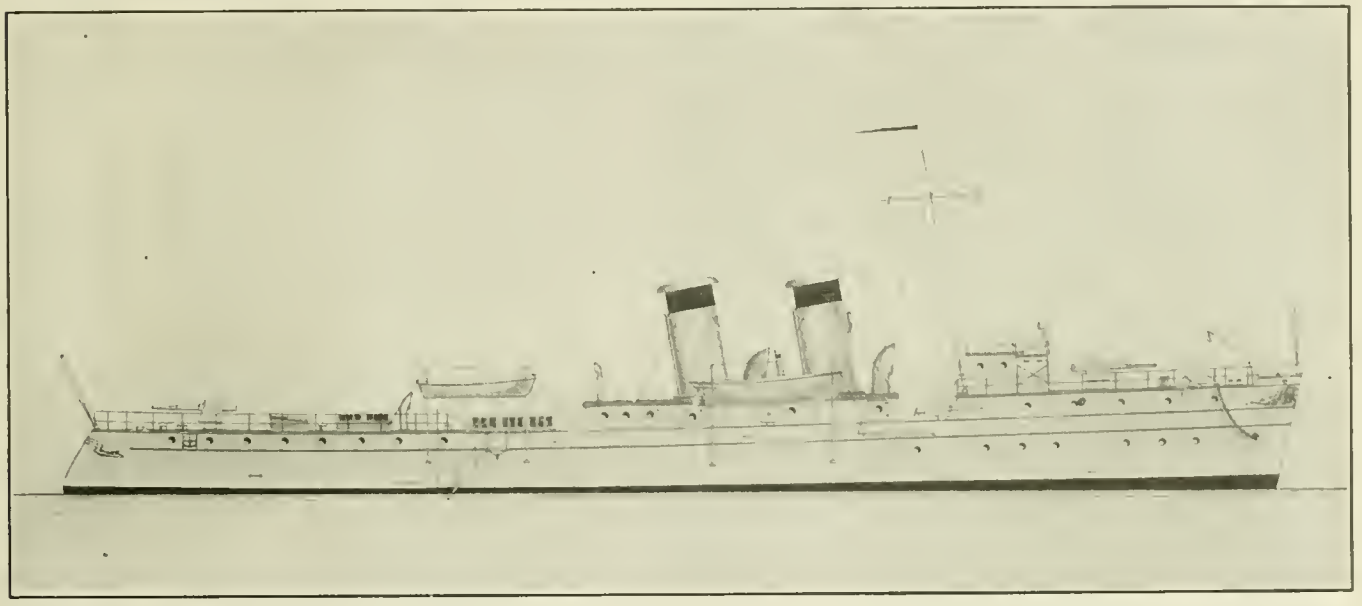
At a time when an impending revolution made it seem necessary for one of the smaller powers in Central America to obtain in a hurry a scout gunboat of high speed, designs were prepared for this craft, which we illustrate herewith. It transpired, however, that matters were settled without the necessity of resorting to any great show of force, and the boat was never built. As indicating, however, the sort of design required by one of these smaller powers for policing its coast, the description may prove interesting.

The design calls for a gunboat of 600 tons displacement, with engines capable of indicating 3,600 horsepower, and giving a speed of 20 knots. The length over all is 210 feet; length on waterline 208 feet; maximum beam 29 feet 6 inches; molded depth 14 feet 6 inches, and draft of water 7 feet. The coal supply was to consist of 175 tons, which was expected to give a radius of action of 1,350 nautical miles at full speed, and 4,800 miles at a speed of ten knots. The armament with which this vessel was to be supplied consists of two 4-inch rifles provided each with 150 rounds of ammunition, and four 6-pounder rapid-fire guns with 500 rounds each. The conning tower and coal-bunker space were protected by nickel steel plates 1 inch in thickness. The complement, which consisted of a total of 60 officers and men, included 4 navigating officers, 4 engineer officers, 6 machinists, and 46 petty officers, crew, coal passers and galley staff.

The assignment of weights was as follows:

	Tons.	Percent.
Hull, complete	210	35
Machinery, complete	170	28.3
Coal	175	29.2
Battery and ammunition	25	4.2
Equipment and stores	20	3.3
Total	600	100

The design was prepared by Mr. Martin C. Erismann, naval architect, of Port Richmond, Staten Island.



TWENTY-KNOT, SIX-HUNDRED-TON GUNBOAT, DESIGNED FOR COAST DUTY.

MOTOR BOATS, IX.

BY DR. WILLIAM F. DURAND.

THE DESIGN OF FORM (CONTINUED).

We come next to the more general and more difficult problem of including changes in the form coefficients as well as in the proportions of L, B and H. Thus it may be desired to change the character of the midship section, to fill in here or fine away there, and so in various ways to modify the characteristics of the original form. In such case it becomes a problem for the drawing board, at least to a first fairing out, before proceeding to lay down the form full size on the floor. The character and extent of such modifications may be judged by three forms of test as follows:

(1) The satisfaction of the eye as a judge of form or proportion;

(2) The satisfaction of the judgment regarding certain desired or suitable values of the form coefficients;

(3) The provision of some needed dimension or space for reasons of structure or arrangement.

If the extent of such changes is not great the original lines, or more especially the body plan, may be taken as a foundation, and the changes lightly sketched in free-hand, fining out or filling in and changing in various ways, until, as judged by one test or another, the desired form is approximately determined. If the body plan has been taken as the base for such changes, then the result on the fairness of form must next be determined by reference to the water lines, bow and buttock lines or diagonals. It will thus be found that, in order to run in smooth or fair lines on the second plan, slight changes must be made back in the sections of the body plan, still retaining of course the fairness of the latter. In this manner it will be necessary to make slight changes back and forth, the changes in one plan being tested by the results in another, until finally both or all plans are as nearly fair as may be determined on the reduced scale used on the drawing board. In making any such series of changes it must be remembered in particular that with a fair form as a foundation a change in any one section, for instance, will necessitate a change in all the water lines in the neighborhood, and hence in order to retain the latter fair, a change in all the sections for some little way on either side of the one first affected.

The operation of thus changing back and forth between two plans, or fairing up, as it is termed, involves many minor points of detail which cannot be here considered, and regarding which experience will be the best teacher. The final purpose in any such design is the determination of a smooth and fair form with the general proportions and form coefficients selected as suitable for the case in hand, and if a form nearly fulfilling the desired conditions can be found as a start, the general procedure above outlined will serve to develop the desired changes.

We may now advance to the general and still more difficult problem of a design new from the start. It is clear that such a design cannot spring from nothing. There must be some form of initial data giving such conditions or characteristics as may serve to make possible a start toward a solution. Such initial data must then be either furnished by the conditions of the problem, or must be assumed to an extent sufficient to make the problem definite and its solution practicable. The features to be thus chosen or assumed may vary somewhat with the choice of the designer. Here as in all cases of engineering design there is no one road leading from the data to the design. There are many routes which will lead from the same starting point to the goal, and the particular route to be taken thus becomes largely a matter of individual choice. For most cases the following may be recommended as a safe and convenient procedure:

The principal dimensions, length, beam, depth, and draft are supposed to be given. The first actual step may be to lay out the form of the midship section. The beam and depth of boat amidships will give the rectangle surrounding such section, and within such rectangle a form of section may be sketched in, having in view the influence of this feature on the design as a whole, and selecting such type as may seem best adapted to the purposes in view. This step is indicated by Fig. 43.

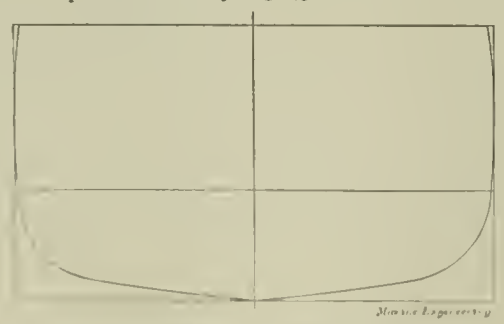


FIG. 43. FORM OF MIDSHIP SECTION.

Having thus selected the form of midship section, the next step may be to run in a sheer line and keel as shown by Fig 44, thus fixing the general contour of the boat in longitudinal section. At this stage the form of stern must be selected, whether with or without deadwood, ship form or torpedo boat form, and the keel line adjusted accordingly. The next step may be to run in a load water line *A B C*, Fig. 45, a rail line *D E C* and a curve of sectional areas *A B C*, Fig. 39. The forms of the load water line and of the curve of sections may be judged either by the eye or by reference to their form coefficients as previously discussed. It will be noted further that the curve of sections is intended to represent the areas of sections up to the load water plane; or in other words that it is intended to refer only to the part of the form lying below the load water line. The maximum ordinate of this curve, *B D*, Fig. 39, must represent therefore the area of the midship section up to the load water line, and the curve of sections should be laid down in a rectangle *A E F C*, of which the

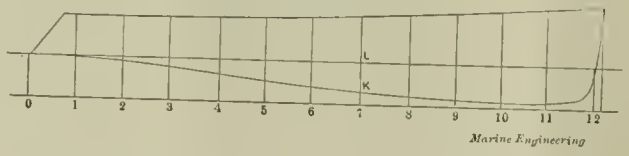


FIG. 44. BODY PROFILE OF MOTOR BOAT WITH TORPEDO STERN.

length *A C* represents to some convenient scale the length of boat on the water line, and the breadth *A E* the area of midship section up to load water line, laid off to any arbitrary and convenient scale. To the same scale therefore any other ordinate, as number 7, will represent the area of the corresponding section of the under water body of the boat.

These three features (deck or rail line, load water line and curve of sections) cannot however be selected independently, but must be taken each with reference to the others, and with reference to its general influence on the design as a whole. If the form has the ship type of stern with deadwood, the curve of sections has the characteristics of a mean or average water line. Hence in such case the deck line will be the fullest in form, the load water line will be next and the curve of sections will be fined away the most. With the torpedo boat stern these same general relations will usually hold for the fore body, while for the after body the form of load water line and deck line will be quite unlike that of the curve of sections. In any case the load water line and rail line must agree at the midship section with the form already determined for this section; but aside from these two points and the ends, which are determined by the sheer plan, these various lines are quite undetermined and must

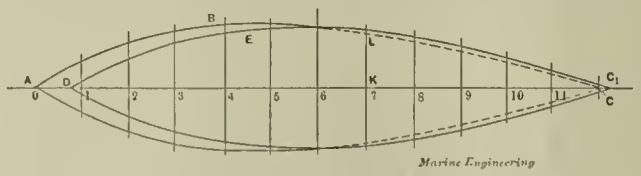


FIG. 45. WATER LINE AND DECK LINE OF MOTOR BOAT.

be laid in with the best judgment available. It is very sure, however, that the lines thus taken will not satisfactorily agree, and that all will require more or less adjustment and accommodation to bring them into satisfactory harmony as features of the design. To determine these points the design must be still further developed, and to this end we proceed as follows:

Take any section, such as number 7, and determine by reference to the curve of sections the area which is called for. Then multiply the depth of section taken from the sheer plan, *K L*, Fig. 44, by the half breadth taken from the load water line, *K L*, Fig. 45. The product will be the area of a rectangle which would just contain the half section in question. Then divide half the area taken from the curve of sections by the area of this rectangle and the quotient will give the fineness coefficient for this section and will show to what extent a rectangle *A B C D*, Fig. 46, with the given depth and breadth must be fined away to give

a half section with area as required. A little experience will enable one to make a close estimate of the shape, knowing the coefficient to be realized. Thus if the value of the coefficient is .72 it shows that $A\,B\,C\,E$ must be slightly less than three-quarters of $A\,B\,C\,D$, and a little experience will make it possible to sketch in a form of section nearly fulfilling these conditions. In any case a few trials checked by planimeter will serve to bring the area to the value desired within a satisfactory limit of accuracy. In thus sketching in the form of section, reference must be made to the midship or principal section, and to the general form of section to be held in view, and also to the point F determined by the rail line, so that the entire section contour $A\,E\,C\,F$ may be run in smooth and fair. In the same general manner the other sections may be run in, care being taken to make the transition in form from one to another not too abrupt, so that the general transition from the midship section fore and aft may be gradual and smooth. For this reason it is also well to start from the midship section, running in number 7, for example, quite similar in form to number 6, the midship section, and only modifying it as may be required by the slight change in area and general dimensions. Next, number 8 is run in with but slight change from number 7, but probably with a growing departure from number 6, and so on to the bow. In the same general manner the after body is determined, both above water and below. In case at any section the various lines as assumed do not agree in such way as to make the form practicable, the fact will be shown by an extreme value of the section coefficient at this point. Thus it might readily result, with the various lines as assumed, that a given section might needs be nearly or quite rectangular in form at one extreme, or triangular or less at the other. In such case the form of the assumed elements must be so adjusted as to give sections throughout having the general character of form desired.

In some cases it may be desired to keep the rail line forward especially full for room on the forward deck, or to give bearing forward when pitching into a head sea. This may be realized by introducing a reverse curve into the forward sections above the load water line, as shown in Fig. 47. In this manner, without increase of under-water body and with relatively fine under-water lines, the desired features may be realized.

When the sections have thus been all sketched in fore and aft, the result will be a set of lines conforming closely to all the conditions thus far imposed; that is, curve of sections, load water line and rail line. It is very sure, however, that a boat built to such lines would not show a smooth and fair surface, but would develop humps and hollows, flat spots and irregular-

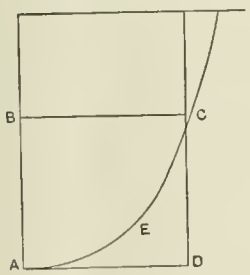


FIG. 46.

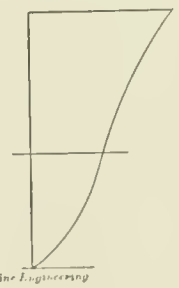


FIG. 47.

ities in a degree wholly surprising to one not familiar with such matters. The next step must, therefore, be the development of a smooth and continuous form, without at the same time sacrificing the conditions already realized as above. The first step in such further program may well be the determination of a series of water lines at from 3 to 6 inches interval, the first being taken perhaps at about mid-draft, and the others, above and below, being run in after such fairing up as the mid-draft line may suggest. The latter, when run in, will probably be found unfair, and will indicate needed modifications in the sections. The same general series of adjustments are then to be carried out as referred to at an earlier point, in connection with the operation of fairing up after making a slight change in a given form. In the same manner other water lines may be run in and faired up, until finally the two sets of lines, water lines and sections, are as nearly fair as may be readily effected with the reduced scale used on the drawing board.

In fairing up the form about the bow and stern, much help may be derived from bow and buttock lines, or from diagonals, as previously explained. The especial advantages of diagonals are as follows: (1.) They often lie approximately in the line of strakes of planking, and thus show how such strakes will be bent, and furnish a test of fairness along these lines. (2.) The intersections of the diagonal cutting planes with the surface are usually not far from perpendicular, and the points in question are thus located more definitely than by the oblique intersections of bow and buttock lines with parts of the surface nearly vertical, or by water planes with parts of the surface nearly horizontal.

The method of developing a new design thus outlined is more especially adapted to cases in which the qualities to be attained may be satisfactorily interpreted in terms of form coefficients and the general characteristics of the curve of sections. In cases where the judgment regarding the coefficient and form of the water line and of the curve of sections may be less certain, or where the designer may prefer to proceed more directly to the determination of form, the same ultimate end may be reached by selecting first a midship section, as before, and then with pencil sketching in lightly the various sections, those of the fore body on one side and those of the after body on the other. Some guidance may be obtained by looking at a body plan with characteristics somewhat similar to those desired, and distributing the sections in a generally similar manner. By working from the midship section each way, and carefully noting the relation of one section to the next, a form may be developed which will be not far from fair, and which will possess the general features desired so far as they may be determined by reference to the sections. The fairness and continuity both of surface and of volume must then be tested by laying down from the sections a set of water lines and a curve of section areas. These will presumably reveal irregularities in the surface form, and in the distribution of volume. With such indications in hand, the sections may then be modified and faired up by means of water lines, bow and buttock lines and diagonals, and in the same general manner as before described. The resulting coefficients of load water line and of curve of section areas may then be determined, and the values applied as a test or basis of judgment regarding the general character of the form thus developed.

The method first discussed involves the selection of certain features and conditions which the form is to fulfil, and as expressed by the form coefficients and the curve of sections, and then determining a form which shall realize these requirements as nearly as may be finally decided desirable. The second method involves the determination of a form direct from the midship section and without other guide than the eye, and then the testing of this form by reference to its coefficients and curve of sections, until the result shall finally be accepted as satisfactory for the case in hand.

In earlier years the forms of boats were commonly determined by working out a model in wood, and to such reduced scale as might be convenient. This method has the advantage of permitting eye judgment of the solid form, and this is always more satisfactory than judgment in the flat, as on the drawing board. It has the disadvantage that the form must be developed almost wholly by eye judgment, and without initial help from the various form coefficients; also, should the form be made too fine at any point, the error is not readily corrected. On paper, lines may be run in and rubbed

out, and the form may be modified in any manner desired, without prejudice to the completion of the problem along any line which may be finally chosen. It is readily seen that with a wood model there is very much less freedom of adjustment and change in this manner, and if patching is to be avoided, great care must be exercised in approaching the final condition, lest a spot undesirably lean may be produced.

If, however, it should be decided to develop the form of the boat by means of a model, such method should be considered only as a first step to the determination of the half-breadth and body plans on the drawing board, and from the latter the coefficients and geometrical characteristics of the form may be determined as previously described. The ordinates, or measurements for laying down these plans, may readily be taken off by calipering, especially if the model is made with lifts as explained below. The form thus produced direct from the model may then be judged by means of these coefficients, especially with reference to the relation between draft, displacement and carrying capacity.

On the other hand, when the form is produced on the drawing board, especially if it contains features of novelty, it may be recommended to make a model before laying the boat down full size and proceeding with the construction. This operation is the inverse of determining the lines from the model. The operation of cutting a model to represent a set of lines is one requiring some considerable skill, and involving many practical details. Within the present limits we may note briefly the following points:

Two general methods of procedure are open:

(1.) A solid block may be glued up, and then pared down as tested by concave moulds cut out to fit the form of the sections, and applied to the model at the corresponding stations. In this manner the block is reduced to the desired form at a series of regularly spaced stations. The intermediate parts are then brought down, and the whole faired up.

(2.) A series of "lifts," or boards of thickness to represent the space between the water lines, is prepared, and the water lines laid out one on each. The lifts are then cut out, each to its own form, and these are then pegged together or glued up, as may be preferred. The corners are then brought down so that the form is smooth and continuous and with water lines as determined. The indications of such a model will often suggest slight changes in the form, and this may be done on the drawing board and followed up on the model, until between the two the resulting form seems to satisfy the judgment taken from all possible points of view.

However the model may be derived from the lines, it may be recommended to always lay up the block out of "lifts" in the manner suggested for the second mode of procedure, and to color the glue with black. This will give on the model definite fine lines in black representing the water lines and aiding the judgment somewhat with regard to the form of the boat along these lines.

In fixing upon the various preliminary characteristics of the design, both draft and total depth will present themselves for consideration. The important question may then arise as to what assurance we may have that when built the boat will come to the draft designed. Definite assurance on this point can be acquired only by elaborate calculations and estimates regarding the weights of boat, machinery and equipment. In the absence of such estimates it may be safely assumed, if the general proportions and character of construction are in accord with common practice, and if the boat is powered within reasonable limits, that there will be left over a certain margin of carrying capacity before bringing the boat down to her designed draft. Such margin may then be utilized for passengers, etc., and should provide for all ordinary requirements with a boat of this character. It is not to be expected, of course, that any boat will naturally or necessarily run at just the designed draft. With small boats, in particular, there is often much variation according to the load carried, and so long as the freeboard remains sufficient for safety, the fundamental purposes of the boat may be considered satisfactorily fulfilled.

THE DEVELOPMENT OF THE TORPEDO-BOAT DESTROYER.*

BY W. J. HARDING.

I think it may be claimed that in building destroyers our nation is pre-eminent, and though shipbuilders and engineers often meet on cosmopolitan ground and compare and freely impart ideas, I think our national egotism may fairly claim that in the matter of construction of torpedo-boat destroyers we lead the world. I would remind you that the River Thames and the Solent first gave us what is called a "torpedo boat," and though the area of production has been very much enlarged, it can certainly be claimed that the productions of those localities are still in the front rank.

From very early times the glamor of the torpedo—or the "infernal machine," as it has been called—has occupied people's attentions and prompted its usage; for the idea is that you may, by a sort of "hitting below the belt," destroy your enemy with but little risk to yourself; and, further, when there is risk involved, it would be borne by only a very small number of assailants, and that in fact, as represented by the novelists and others, risks to each individual may be less than that of the players in a football scrimmage.

I need scarcely say that torpedoes may be classed as fixed and moving. Of the fixed ones our experience as a nation was gained during the Russian war of the fifties, when at least one of our ships was slightly injured in the Baltic by the explosion of a torpedo under her, and some officers and men were injured by the explosion of captured torpedoes while they were being taken apart. During that war also was used what may be described as a moving torpedo, one of our sailor men being credited with swimming into the harbor of Sebastopol and fixing an infernal machine under the counter of a line-of-battle ship, for which bravery he was rewarded; but I believe the ship was not blown up.

In 1858 our navy had experience of a moving torpedo, a Chinese invention. H. M. S. *Niger*, while lying in Fatee Creek ready for the bombardment of Canton, was torpedoed by a moving junk filled with gunpowder, etc., towed from each bank of the stream and cleverly placed under the bow of the *Niger* and exploded. The damage inflicted was more moral and intellectual than physical. And of other fixed and moving torpedoes we have lately had knowledge in the operations in the far eastern seas.

I may also remind you that the moving torpedo, carried on the end of a spar, was used during the civil war in North America, notably when Commander Cushing blew up the Confederate warship *Albemarle*. Another attack by the Confederates, in 1864, with the spar torpedo, was successful in sinking the Federal man-of-war *Housatonic*, the attacking boat being sucked into the breach made by the explosion and also foundering with all hands. Also during that war there were several cases of ships being destroyed by anchored mines.

After that we had the Harvey towing torpedo, which was an adaptation of the canal barge towed from the bank, or of what is known as the salmon poacher's "otter" with baited hooks, the poacher walking along the river's bank and towing his otter, which keeps mid-stream, and so catching his salmon. These otters can also be made to alter the direction of their motion by a strong pull on the towing line, which enables the poacher to retrace his steps, still towing his otter mid-stream. After that we had the Whitehead invention, which has necessitated alterations and additions both to tactics and to shipbuilding.

*Read before the Institute of Marine Engineers, March 13, 1905.

Not always has perfection been obtained without early fatalities. We had in our navy a very promising officer, Lieutenant Meade, brother of the present Earl Clanwilliam, blown up when manipulating a torpedo of his own invention in the sixties. And later on in the seventies, we had an engineer officer killed and another maimed in working the Whitehead apparatus, due to escape of compressed air. There have been other incidents giving maiming of limbs, which is a toll learners have had to pay in manipulating these and other deadly weapons; and happily the history of our navy shows that whether boiler explosions, machinery disasters, or other incidents giving mortality, there are always many living volunteers to take a dead man's place.

The Whitehead torpedo is fairly well known. This is the invention of a marine engineer, and is a weapon which marine engineers are most aptly fitted to manipulate. Its original propelling apparatus was by compressed air working compound oscillating engines and driving a single propeller, giving rather a low speed.

The first vessel in the British navy for using this torpedo was the *Vesuvius*. This was a vessel low in the water, having a peace funnel of the ordinary type pointing to the sky and a war funnel horizontally along her deck to discharge smoke right aft. She was fitted with induced draft. She had a submerged torpedo tube pointing right ahead, from which the torpedo was ejected by a telescopic apparatus actuated by compressed air. It was early seen in this vessel that the speed of the torpedo should be increased, for it is one of the legends of the navy that when she did fire an actual live torpedo from her tube at a hulk, she being under way, those looking over the bows of the vessel saw that the *Vesuvius* would soon overtake the torpedo, and perhaps be blown up herself. Higher speeds of torpedo were afterward obtained by adopting the Brotherhood three-cylinder engine, and this has been continued.

The development of the torpedo boat and destroyer is due primarily to the fact that it was found that these Whitehead torpedoes could be discharged from above water. The first experiment was made from the deck of an old sailing vessel, the torpedo launched, and the regulating valve for the engine tripped as it passed over the side, when it was seen that the torpedo dived and soon regulated itself to the depth required and propelled itself in a straight line. From this was evolved the ordinary deck torpedo tube now used in torpedo boats and destroyers.

The torpedo "drop gear" fitted to vedette boats, etc., was an adaptation invented by Engineer Rear-Admiral J. T. Corner, and is an arrangement of tongs which is lowered from the boat's side, submerges the torpedo, and on tripping its regulating valve, thus setting the propeller in motion, releasing the tongs at the same time, the torpedo starts and soon finds its depth. These vedette boats of wood of 1878 were 48 feet long and 12 knots speed, and have been developed to 56 feet long. Special boats of this class, by J. Samuel White, of Cowes, have obtained 19 knots on trial.

About 1873 some very fast vessels began to be constructed on the Thames. These vessels were marvelous in their low weight and high power. They completely upset the theories which are written in some books on naval architecture, in which it was laid down that speed at sea could be obtained only by enormous increase of dimensions of the vessel, and it was inferred that the speed of small vessels could be put to only a certain limit, dependent on length.

In 1875, Messrs. Yarrow constructed a torpedo launch of the then high speed of 13 knots, fitted with a spar torpedo, and made a war test by blowing up a barge on the Thames prior to shipment and delivery to a South American power. Sir John Thornycroft was the builder of the *Miranda*, in 1872. This vessel was 45 feet 6 inches long, and obtained a speed of 16.2 knots per hour. This firm constructed the first large torpedo boat for H. M. Navy. She was the *Lightning*, completed in 1877, her length 87 feet, speed 18 1-2 knots, and she did many years of constant service at Portsmouth. Also in 1877 the Russian government obtained from home and two foreign firms 100 torpedo boats. A large number of these were built by, or to the design of, Messrs. Yarrow, celerity being required. They were 75 feet long by 10 feet beam, were required as small as possible for keeping the seas for a few days, and also adapted for transmission by rail. The first boat tried on the Neva obtained 18 knots speed.

Following the *Lightning*, various batches of boats for our navy were constructed at various times up till 1889. These were by Messrs. Thornycroft, White of Cowes, and Yarrow. Their lengths were from 113 feet to 130 feet, giving horsepowers from 730 to 1,100, and speeds from 20 to 23 knots. Some of the earlier and shorter of these were dispatched to various stations—China, Cape of Good Hope, Australia, North America, India, etc. Most of these voyages were under their own steam. The longest

UNITED STATES TORPEDO BOAT DESTROYER WORDEN AT FULL SPEED.

voyages, from England to Vancouver Island via Sandy Point, were performed by two Yarrow boats. There were no incidents during these voyages engendering mistrust as to strength of hull. As to the crews, their normal state may be described as "dirty, but happy." In connection with this matter of strength of hull, of the destroyer class especially, it is much to be regretted that alarm was some few years ago created by irresponsible and untechnical writers—some of them neither naval nor expert, though called naval experts—who argued from wrong premises and preached ideas which, if followed, would cause a most useless and wasteful expenditure of public money.

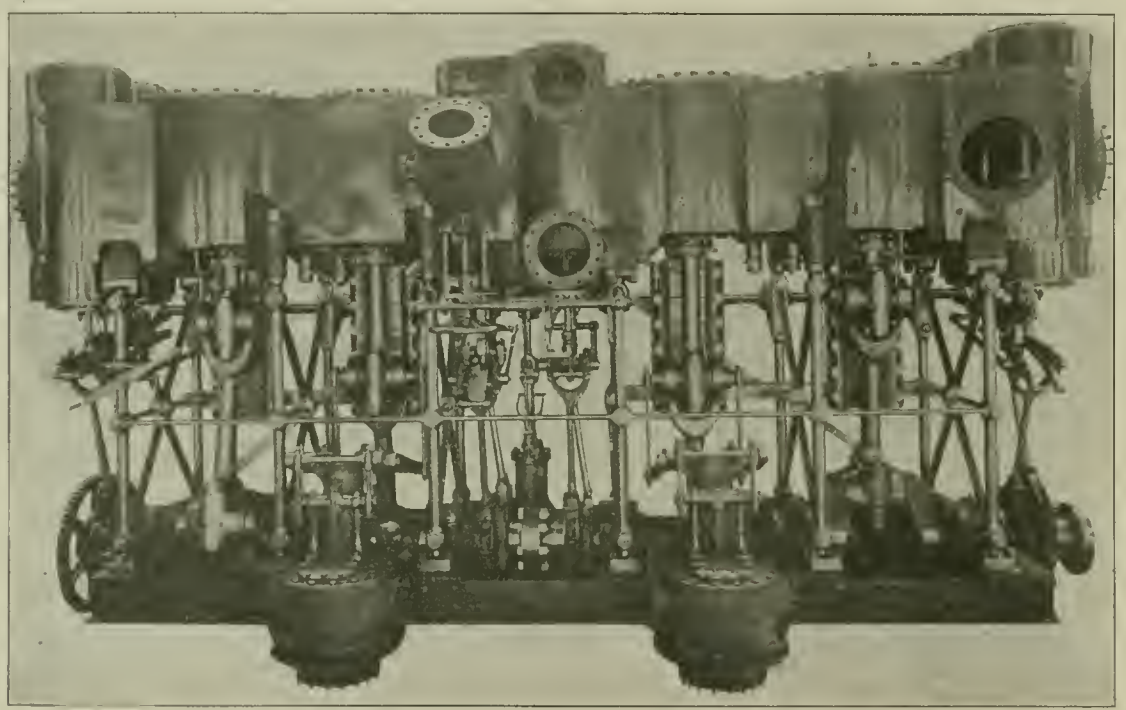
In the Chilian-Peruvian war, 1879-1881, spar torpedo boats were employed by both combatants. The blockade of Callao was commenced at about 5 A.M. on April 10, 1880, by the Chilian Thornycroft torpedo boat *Guacolda,* an 11-knot craft, attacking the Peruvian man-of-war *Union,* which was surrounded by timber booms. The boom was shattered, but the small-arm fire drove off the torpedo boat.

The gallant but unready Peruvians had only makeshift craft, which did good work, in that they caused the Chilian blockading fleet to proceed to sea daily at sundown and spend the night in a safe offing, the entrance to Callao Bay being patrolled by Chilian torpedo boats. In the middle watch of May 25 of that year, a Peruvian spar torpedo launch, some distance from the shore, was surprised by the *Guacolda,* which chased her. The 18-knot Yarrow boat, the Chilian *Janeques,* also chased and overtook the Peruvian, the result being that the Chilian was torpedoed and sunk, and the Peruvian foundered when returning. Gallant Lieutenant Galves, badly wounded, and seven of his crew of sixteen were rescued by the *Guacolda;* his surgeon, Uriarte, and eight men were killed. The surgeon was given an impressive public funeral in Lima. The Chilian loss was two men, the remainder escaping in boats seized from a vessel lying in the out-of-fire zone.

It will be remembered that this war was remarkable for the destruction of two vessels by torpedoes. In one case the transport *Loa* captured a coasting barge adrift full of vegetables, fruit, poultry, and other good things, which were heartily welcomed by the crew, who had had a long diet of sun-dried beef and biscuit. On examination of the barge it did not show any explosives; but as the welcomed cargo was unloaded from the barge alongside the *Loa,* mechanical arrangements were such that when the weight in the barge had been very much reduced an explosion ensued, which blew in the side of the *Loa* and sank her with loss of life of 145 men of a crew of 200.

Another case was the *Covadonga.* She had been captured from the Spaniards by the Chilians many years before by a deception, and another deception was her doom. This vessel captured a little skiff which was adrift, and, in hoisting her on board the *Covadonga* was dynamited and sunk. There were moving torpedoes supplied for that war, but they did no destruction. They were of the "awash" principle, controlled from a station by wire. They were not regarded as satisfactory by the Peruvians. In one case it is said that one got out of control and returned toward the Peruvian ship *Huascar,* from which it was being operated, and only the gallantry of Lieut. Diez Canseco of that ship saved her, he jumping overboard and diverting the torpedo. The Peruvian Admiral Grau was so disgusted by these weapons that he landed them and buried them in the public cemetery at Iquique.

Later, in 1891, in those South Pacific waters, the Whitehead was used. In one case a Whitehead was fired from a picket boat at a large Chilian mail ship, but did no damage, being found next morning minus its head, no explosion happening. But the ironclad *Blanco Encalada* fared worse. Some six Whiteheads were fired at her, of which one only seems to have struck, and its charge of 58 pounds of guncotton knocked a hole in her side 15 feet fore-and-aft by about 7 feet high. She sank in less than five minutes, losing 150 officers and men. Of the eleven officers missing six were engineers. The only engineer who was saved was washed up one of the ventilators. Later on in that war a spar torpedo picket boat was destroyed by the explosion of her own torpedo, and five men were blown up or drowned.



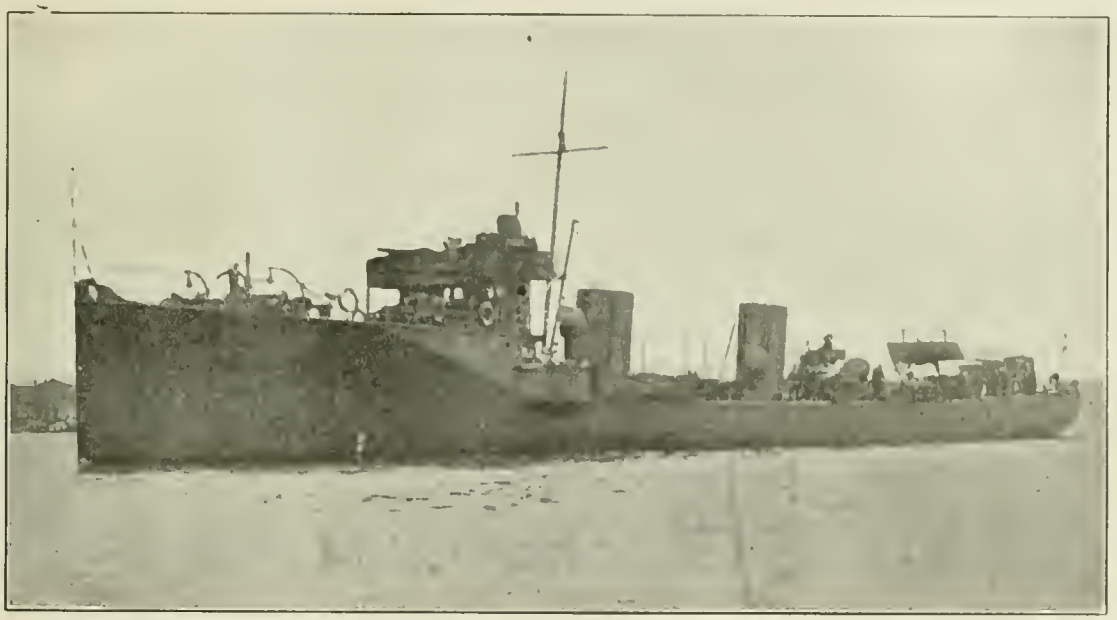
FRONT VIEW OF ONE FOUR-CYLINDER TRIPLE EXPANSION ENGINE OF WORDEN.

In 1893 torpedo warfare was conducted on the Brazilian coast. The ironclad *Aquidaban* was struck forward by a fish torpedo having 125 pounds of guncotton, which caused the two forward compartments to fill but did not sink her. In this case one hit in four discharges was given.

The precursor of the destroyer class was evolved about 1884. Hitherto the plan had been to give torpedo boats an alternative armament, so that half of the boats might be employed for firing torpedoes, the others acting as torpedo-boat destroyers, the boats

armed by the small guns resisting attacks of torpedo boats. But as the speeds would be about the same in each, it is evident that neither could decrease the range of the other when attacking or escaping. Perhaps the first approach to the destroyer was the production of John Samuel White, of Cowes. This was a vessel added to the British navy in 1885. She was 150 feet long, and so larger than boats hitherto in use, which were single-screw boats. She was fitted with twin screws and with more power—a larger vessel and better sea boat and of higher sea speed than they. In the British navy she did good work as the commodore of the flotilla.

Another vessel, 200 feet long, 2,900 horsepower, named the *Sea Serpent,* was also laid down by that firm in 1885, and obtained a speed of 23.8 knots with a load of 20 tons, and 21.5 knots with a load of 90 tons. The curt term "destroyer" not then being in use, she was termed an "exaggerated torpedo boat." At that time *Rattlesnakes* were in fashion, but the "exaggerations" are now a survival of the fittest. Her speed was a little disappointing, the shallow water of Stokes Bay not favoring speed. Also, if subsequent knowledge as to material of propellers had been available, she might have obtained 25 knots, and so fulfilled most of the conditions which were afterward required in torpedo-boat destroyers. She was eventually acquired by the Chinese.



BRITISH RIVER TYPE TORPEDO BOAT DESTROYER EXE.

Messrs. Yarrow & Company constructed the *Kotaka* in 1885 for the Japanese government. She was 170 feet long and fitted with twin screws, and practically an armored destroyer, being fitted with armor 1 inch thick around the machinery and boiler compartments, sufficient to resist the fire from the torpedo boats as then armed. This vessel led the attack, with other torpedo boats, on the Chinese ships at Port Arthur. It is not generally known that in that Japanese attack the weather was so bitterly cold that it actually froze the sea-sprayed torpedoes in their carriages, and that of eight torpedoes which were attempted to be fired against the Chinese men-of-war only two were actually fired, the others being frozen in their tubes, and could not be ejected till thawed out. Perhaps in reference to this incident I may suggest that the recent operations in China seas have also been very much influenced by the freezing weather, for engineers well know that compressed air in escaping is frozen, and that where compressed air is used for operating machinery the exhaust pipe must be very short, and to carry a Whitehead charged with compressed air which will rapidly assume the temperature of the surrounding atmosphere, which may be initially several degrees below freezing point, this expanded air exhausting from the Brotherhood engine through a long hollow propeller shaft, may cause such freezing in that shaft as will decrease the speed and range of the torpedo, and perhaps render it inoperative.

About 1893 the British navy gave orders for torpedo boats which were to be of higher speed than hitherto; and not only of higher speed, but to obtain this speed carrying a greater load than before. These boats were *Nos. 88* to *97* of our navy, constructed by Yarrow, Thornycroft, and White, and one of them by Laird, of Birkenhead. Some were fitted with locomotive boilers; those by Thornycroft with water-tube boilers; one by Yarrow also with water-tube boilers. Trials of these vessels showed that certainly for this service the water-tube boiler was far preferable to the locomotive boiler.

About this time also the "torpedo-boat destroyer" was evolved. Practically these destroyers were given just double the power of the latest torpedo boats in being. The hulls were built round them with due regard to the armament and the weight to be carried on trial, and also, of course, with due regard to the fact that they would be expected to be more sea-going. The draft was restricted to 5 feet, giving immunity from destruction by Whitehead torpedoes, which are erratic and inclined to "porpoising" if set to run at 5 feet depth or thereabout. They were armed with guns and Whiteheads, and so were calculated to destroy not only torpedo boats but battleships. This batch of destroyers, originally confined to Yarrow, Thornycroft, and White, was afterward spread all over the country. They are fairly well known to most engineers. These expanded an industry which required high technical knowledge and superior handicraft.

Observers of the building of these hulls will note that with the very thin plates as used it is absolutely necessary to manipulate those plates to give the requisite strength to resist any alteration of form. A five pound plate—that is, ⅛ inch thick—is a very limp object when received from the cogging mills, but after it has passed the leveling slab and been leveled it becomes very stiff; and its actual tensile strength is not in any way altered, while its strength to resist bending is very much increased, the leveling or "planishing" rendering the plate extremely stiff; and it is this knowledge of building among the workmen employed which is noticeable in various vessels, those built from longer experience being certainly stiffer and better vessels than those not having the benefit of that experience.

This paper is not intended to enter into the dimensions of scantlings employed, but perhaps it would be interesting to note that in the 27-knot destroyers built of galvanized mild steel

plates, with tensile strength 30 tons, the thickness of garboard strake is 6½ pounds; sheer strake, 9 pounds; deck plating, 6½ and 8½ pounds per square foot. Afterward a harder and stronger steel was used, which was more difficult to manipulate. This increased the cost of building, but permitted lighter scantlings, comparatively. This latter steel was 40 tons tensile strength. Its riveting was much more difficult with the hard rivets used; they required more knocking down, and the riveting was not so comely and smooth.

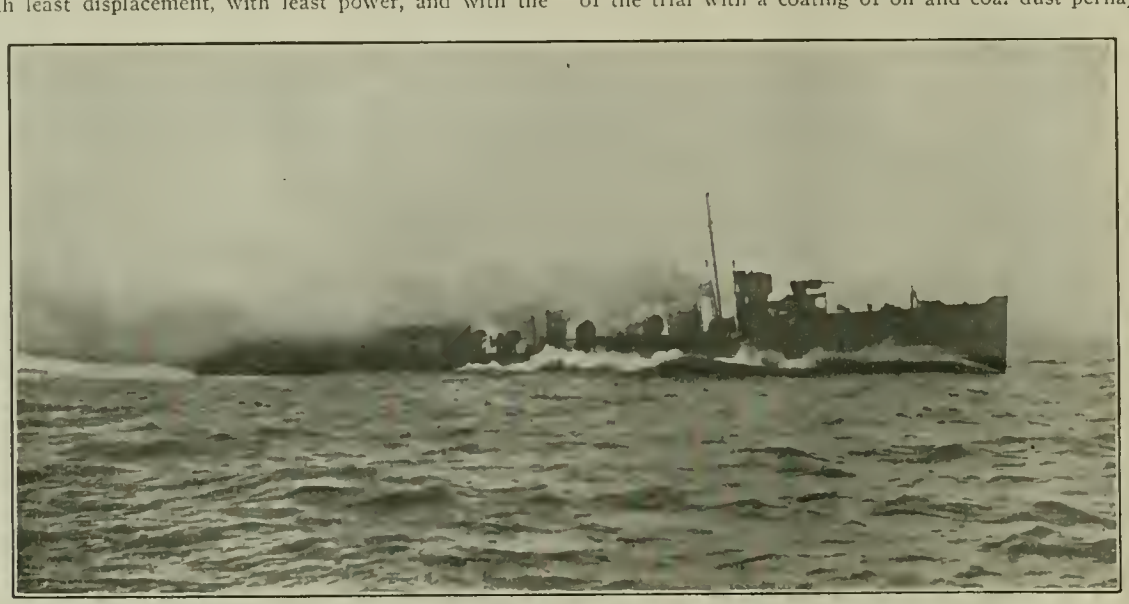
These 27-knot destroyers were of various lengths from 180 to 190 feet, the horsepower varying from 3,700 to 4,800. It may be mentioned that there was great public interest aroused, not only by the ordering of these boats, but from the fact that some men who seemed to have knowledge actually expressed their views as to the speed being unobtainable; and in one case simultaneously with such assertions that the speed was not obtainable there came the actual news that the *Havock*, by Yarrow & Company, the first of the destroyers, had obtained a speed of 26.2 knots. This vessel (length 180 feet, beam 18 feet 6 inches, depth 10 feet 6 inches, and displacement 240 tons) showed what could be done with least displacement, with least power, and with the least coal consumption, toward carrying the armament required at the speed required. The larger vessels carrying the same armament with greater power and with a much greater coal consumption also gave the same speed of 27 knots; and though it may be asserted that the large vessel has advantages over the smaller one, primarily in the matter of habitability, I would put it that the vessel doing the work on the least displacement and with least coal consumption is certainly a triumph of brains, if nothing else. I also think that such a vessel should initially cost less than a larger one—certainly she should cost less for maintenance.

One important improvement introduced by Mr. White, prior to the year 1883, is a feature in all subsequent torpedo boats and all destroyers. This is the cutting away of the dead wood at the stern, thereby securing a maneuvering power that would otherwise be scarcely possible, coupled with a more efficient feeding of the propellers so essential to high speed. It is well known that from 1891 to 1896 the trials of the 27-knot destroyers were chronicled in the newspapers, and each seemed to go one better than the other.

In the matter of speed, the highest on the measured mile was given by the *Boxer*, by Thornycroft, the speed obtained being 29.1 knots with 4,490 horsepower. In the matter of coal consumption, the lowest was the *Hornet*, by Yarrow & Company; she burned 9,322 pounds per hour, giving 27.6 knots, the highest burning 17,122 pounds per hour, giving 27.4 knots.

All these trials were full of very interesting incidents, and one thing they taught was that the very best material, and certainly the very best workmanship, was indispensable, coupled, of course, with the most talented brains in the drawing office. For the "spoke-shaving" was such that between success and failure was almost at times just the thickness of a sheet of paper. In the matter of machinery trials numerous incidents might be mentioned. I should like to say this, having observed some of the trials—and I am not alone in my opinion—that the way in which youngsters, apprentices, and young journeymen, tackled the duties which were placed upon them, and tackled them with a knowledge that occasionally there were accidents which might produce maiming, was certainly good to observe from a national point of view.

Better pens than mine have told of the fair-haired public school boys and others doing their duties among the machinery in a most laudable manner, including the son of a belted knight in the stokehold oiling the fan engines, and certainly covered at the end of the trial with a coating of oil and coal dust perhaps weighing 2 pounds to the square foot of flesh and clothing; and I might also mention one case of several apprentices who did the coal trimming in the bunkers for a long trial rather than forego the trial by waiting for coal trimmers who did not turn up. So much for the personal element.



BRITISH DESTROYER BOYNE AT FULL SPEED ON TRIAL TRIP.

It was my great honor to take Mr. Rudyard Kipling into the engine room of a Thornycroft destroyer on trial. He seemed to be much impressed by seeing engines with 18-inch stroke doing 400 revolutions in an apparently small space, the eight connecting rods each making 800 swings a minute, faster than the eye could follow. He said that he had come to the conclusion that the youth who wished to become an engineer was prompted not so much by love of pelf, but from seeing the creations of engineers do such work as this and to be identified with it. He also compared the engine room with the 500 bewilderments of ill-livers deceased, as preached in some tenets.

I might mention many incidents which occurred during these trials, showing that high-grade workmanship was required, and also showing how negligent workmanship cost many golden sovereigns to the shipbuilders. Boilers, engines, condensers, shafting, and screw propellers, all gave little troubles, and all gave valuable pointers for improvement in the future.

As regards the boilers, it was proved that the locomotive boilers gave excellent results up to a certain grade of coal burning, and at

slow burning they were very economical, but the tube ends could not be depended on to remain tight. These troubles were not experienced in water-tube boilers, which were of various systems, some with straight and some with curved tubes. Practically all showed their superiority over any type of locomotive boiler which had hitherto been used, when forced to the utmost extent of their coal-burning capacities. Nevertheless, the locomotive boiler gave 1 horsepower for 1.33 square feet of heating surface, as against a maximum of 2.58 square feet in a water-tube boiler.

Usually incidents in the engine room were due to inefficient lubrication. It is generally well known that the oiling was supplemented by men with syringes, and there was no stint of oil. So large a quantity was used, that, if named, it might cause a great deal of horror to those who are wont to be economical in the engine room. I can, perhaps, mention only that in a foreign destroyer, modeled something after the English pattern, the engine-room department is credited with having used 450 gallons of oil in three hours, so that at least they must have been pretty attentive to the oiling. Our records do not chronicle such a high consumption.

If the white metal of the crank-head at any time ran, it was very advisable to stop the engine dead, as otherwise unpleasant consequences ensued. Generally it may be said that all oiling arrangements were made with a view to keeping oil in the journal. That is to say, the oil channels were stopped short at the ends of the bearings, and the liners between the brasses were in some cases made to fit close, if not touching the crank pins or journals, so that the oil could all be retained between the rubbing surfaces, and only weep away at the ends.

Some trouble was experienced with surface condensers, principally in the matter of split tubes, some splitting before, some splitting during, and some splitting after a trial—as a consequence producing boiler trouble from brackish feed. I think it may be said that the troubles of water-tube boilers arise primarily from faulty surface condensers, and had satisfactory condensers been in vogue when water-tube boilers were first adopted, there is no doubt that much public discussion on the great water-tube boiler question would have been avoided.

The form of surface condenser used in destroyers is well known, a few having double flow of circulating water and the majority having a single flow. My opinion is that those having the double flow—that is, having short tubes—have given less trouble than those having the single flow with long tubes. Even the most hypercritical inspections and testings of condenser tubes before building the condenser failed to obviate all trouble. There is such a little difference between those tubes which act well and those which act badly that it can hardly be detected. Toughness, combined with requisite hardness, is what was aimed at, and in some cases hardness verged on to brittleness, and brittle tubes became split.

The quality of the material may be fairly well tested by taking a short piece and cracking it in a vise. Those which compress to a certain limit and crack in only two places give better working than those that compress and crack in three places. A good, tough tube of the required hardness should be capable of being flattened with water pressure test of 300 pounds inside of them without fracture, and pieces flattened in the vise should bear a certain amount of flattening without fracture, and the alteration in dimensions at fracture should point as to the quality of the tubes. It is well known that in the larger ships of His Majesty's navy, it has become a practice to fit two condensers to each engine, so that if one becomes defective and gives salt feed it may be shut off and rectified, the remaining condenser giving a fair amount of power, though reduced.

I look forward to the time when our present Hall's surface condensers will be abolished, and I have had an opportunity of seeing an invention toward this end. By the kindness of Messrs. Caird and Rayner, I have viewed a new type of condenser, which will enable condensers being built in groups each of 1,000 horsepower, and each and every one of these may be disconnected at any time for examination and repair, whereas with the present surface condensers examination of the thousands of square feet of internal and external surfaces of the tubes is almost an impossible operation. With the condenser of Caird and Rayner, I note that such may be taken apart in a few minutes, and the whole of the internal and external surfaces of the cooling area examined, corrosion noted (if any), and the surfaces cleaned and rendered efficient.

UNITED STATES DESTROYER MACDONOUGH ON TRIAL TRIP.

As well as split tubes in the torpedo-boat destroyer's condensers, we have had occasionally ferrule slackening, due, no doubt, to vibration. This was overcome in some cases by the invention of the Thornycroft ferrule. Of all the systems, however, I prefer the Yarrow system, in which the tube goes right through the ferrule and has a small wire guard to prevent slackening of ferrule, and it has the great advantage of giving an unimpeded flow of a full bore of water through the tube. The ordinary ferrule now in use would not give this, as there must be some eddying at the entrance of the tube.

Occasionally there were twisted shafts, about which there were many opinions, some holding that the shafts were not strong enough, and some holding that the longitudinal vibration of the vessel tended to seize the shafting in the bearings, and so produced twisting.

Most valuable lessons in fatigue of metal were learned. Stresses which, if once applied, would give no indication of ultimate fracture, were found to produce fracture after thousands of

such stresses. These were principally by bending. I may mention that in bolts with reduced shanks, which were supposed to stretch a lot before breaking, I never saw any such stretching, the bolts generally fracturing near the end of the screw thread. Had there been such stretch of material, some disasters might have been averted.

But above all, those trials gave most valuable lessons in screw propellers. It had been customary in torpedo boats and prior boats to make propellers of forged steel, but the substitution of manganese bronze propellers of practically the same dimensions gave the then marvelous result of an increase of speed of about two knots. At 384 revolutions per minute the forged steel propeller gave 24¾ knots; the manganese bronze propeller at the same revolutions gave 27 knots in the same vessel at the same draft.

Other items as to the various ratios to be used—namely, the ratio of pitch to diameter, and the area of the blade as compared with the area of the propeller disk—also became apparent, showing the direction in which improvement might be effected, as well as indicating other suitable dimensions. Generally, the knowledge gleaned was that each time the propeller was fined there was a gain, and each time the propeller was decreased in diameter.

UNITED STATES DESTROYER BAINBRIDGE MAKING 29 KNOTS ON TRIAL TRIP.

meter, retaining the same pitch, there was a loss. To a certain ratio the area of the blade could be increased with advantage, provided the engine would turn the propeller round. Practically, whenever the slip was decreased by fining the propeller or by fining and increasing its diameter, or perhaps by fining, increasing its diameter, and adding more blade area, there was an improvement not only in speed, but in the coal bill.

Vibration was found to be modified by the propeller used, by the position of the blades with respect to the cranks, and by pitch deviations in each blade. The speed of no slip was important.

These experiments showed that if only the indicated horsepower were required, the propeller could be fitted which would give perhaps 20 percent more horsepower than an ordinary propeller. If the speed were required, a very different propeller would be adopted; but if speed coupled with a small coal bill were required, the propeller between these two would give the best results. Also that the proportions of the propeller influenced the coal per indicated horsepower, the coal per indicated horsepower propeller lacking in propulsive effect. The least immersion of the propellers gave the best results both in speed and coal bills; and the distance apart of twin-screw propellers was of moment.

I may give comparative instances of propellers showing how improvement was given: (*a*) diameter increased 4 percent, area increased 19 percent, pitch not altered, the coal bill was decreased 27 percent at equal high speeds; (*b*) pitch fined 6 percent, no other alterations, gave the same high speed with 10 percent less indicated horsepower, and 17¾ percent less coal bill, (*c*) diameter increased 2 percent, pitch fined 9 percent, gave ¾ knot more speed, and coal bill decreased 40 percent at the same high speed obtained by the first propeller.

I suggest that the torpedo-boat destroyer experiments might be regarded as model experiments on a very large scale, of which the expense was borne by the contractors, and the result is that many larger ships, both naval and mercantile, are now having much more efficient propellers fitted—perhaps from this experience. The words of Sir W. H. White, uttered twenty-one years ago, were prophetic: "In these torpedo vessels we have no doubt the pioneers of future navigation at higher speeds than have ever been attained."

The load carried on these 27-knot destroyers was 30 tons. This was a task heavier than had hitherto been the practice in any navies.

In this matter of propellers it will thus be seen that when 27-knot destroyers are loaded down to their war-service draft their trial-trip propellers are practically unsuited for that draft, and the loss of speed which ensues consequent on the choking of the propellers due to increased draft and displacement, is noticeable, and gives some disappointment.

I am of opinion, however, that all 27-knot destroyers could even now obtain better sea-speeds if they could be fitted with propellers different from their original ones. But this is a very complicated question, as it will be seen that a propeller which may enable the engines to do their speed, we will say, of 400 revolutions a minute with a fully loaded destroyer, may let those engines run away in an undesirable manner if she be lightened to nearly empty bunkers and magazines. New deep-draft propellers provided by the original constructors of the vessels would doubtless give increased speed with lessened coal bills, which would soon pay for this small outlay.

Those 27-knot boats gave an indication that the depth of water in which measured mile trials were run was of very great moment in results obtained. Practically in the same vessel run on two different measured miles, one locality would require fewer revolutions per knot, and the engine not so much loaded as the other. In this respect there is no doubt the measured mile at Wemyss Bay is the best. Those destroyers which obtained their speed in

shallow water have generally given better sea results than those which obtained their speed in deep water.

Experience gained in the 27-knot destroyers was of great use when faster ones of 30-knot speed were required.

During the construction of the 27-knot destroyers Messrs. Yarrow & Company produced the *Sokol*, a destroyer for the Russian navy. This vessel, 190 feet long by 18 feet 6 inches beam, obtained a speed of 29¾ knots in the shallow water of the Maplin Sands measured mile, and so proved herself superior to all British destroyers. Probably if she had run at Wemyss Bay she would have approached 31 knots. She was the precursor and pattern of a large number constructed in Russian yards.

The terms of the trials for the 30-knot destroyers were very much amplified, for whereas in the former 27-knot destroyers there were no reserves of coal consumption, in these it was intended that 2½ pounds per indicated horsepower per hour should be a standard. This was much less than the average of the former 27-knot destroyers. Messrs. Thornycroft & Company obtained the first record for 30 knots in a British naval vessel at the Maplin Sands in the *Desperate* in April, 1896. The vessel was loaded as per contract, and ran this trial in a stiff gale with all wind resistances, boats, etc., in place. Various contractors throughout the kingdom followed on, and in most cases fulfilled the contract without very much exertion. There were, as before, a few incidents arising from unforeseen circumstances, but take it all round the 30-knot destroyer gave less trouble than prior ones.

Two other destroyers of higher speeds were also produced, the *Albatross* by Thornycroft, and the *Express* by Laird. The former obtained a speed of 31½ knots with indicted horsepower of 7,700. This was at the Maplin Sands, where the drag of water, due to shallowness, became very apparent. The latter was tried at Wemyss Bay.

The 30-knot destroyers were followed by a reaction in favor of stronger vessels, now known as the river class. These vessels are of about 550 tons displacement, 200 to 230 feet long, and horsepower 7,500. They are much more costly than the 30-knot destroyers, and though their speed of 25½ knots was obtained in deep water, I am of opinion that, as before mentioned in my remarks, if the 30-knot destroyers had different propellers fitted they would outrace all the rivers at war-service lading with a smaller coal bill.

The following table, taken from a parliamentary return, gives information of the river class:

TABLE 1.

River Class Destroyers	By whom built	Speed obtained on full speed trials Knots	Coal per I. H. P. on the high speed consumption trial Pounds per hour	Air pressure on full speed trial Inches
Welland	Yarrow & Co.	26.2	1.65	1.8
Usk	"	26.1	1 77	1.6
Teviot	"	25.9	2.07	2.0
Ribble	"	25.8	1.57	1.6
Exe	Palmer's Co.	25.6	2.11	2.4
Waveny	Hawthorn Leslie	25.6	2.19	3.2
Derwent	"	25.7	2.24	2.8
Erne	Palmer's Co.	25.6	2.25	2.5
Dee	"	25.5	2 28	2.6
Eltrick	"	25.6	2.33	2.6
Cherwell	"	25.6	2.34	2.7
Kennet	Thornycroft & Co.	26.0	2.39	3.8
Jed	"	25.7	2 46	4.0
Itchen	Laird Bros.	25.6	2.46	4.3
Blackwater	"	25.7	2.62	5.3
Arun	"	25.7	2.68	4.4
Foyle	"	25.6	2.79	4.4
Eden (turbine)	Hawthorn Leslie	26.2	tons cwt. 7 9 per hour	3.3

I should mention that the latest torpedo boats, Nos. 89 to 117, were tried at their deep-sea draft, and obtained speeds of 25 knots, with an average horsepower of about 3,000. These vessels are superior to earlier torpedo boats, and being 165½ feet long (about 9 beams), are good sea boats.

The newspapers tell us that a destroyer of 33 knots is again contemplated, and it will be apparent that very high power will be required. The following table will show that in the 20-knot

TABLE 2.

Vessel	Length Feet	Speed Knots	I. H. P. per ton of displacement	Propellers
Miranda	45½	16	14.7	Forged steel
Torpedo Boat	113	20	10.6	"
"	125	21	10.6	"
"	130	22	12.9	"
"	140	23	15.6	"
"	140	23	13 0	Manganese bronze
"	165¼	25	15.0	"
River class	220	25½	12.6	"
Destroyer	185	27	15.7	"
"	215	30	20.0	"
"	228	31½	21.1	"

boats of the eighties it required 10½ horsepower per ton of displacement, and so on through each batch of vessels as they became larger.

In conclusion, I may be permitted, perhaps, to express a few opinions as to the utility of these vessels. As I have said, they appeal to marine engineers, because the Whitehead is a marine engineer's invention and is a weapon which all marine engineers can well manipulate; and I think that if a Coast Volunteer Corps could be established, composed largely of young marine engineers, for service in these vessels as coast defenders, not only the manipulation of the machinery and of the Whitehead, but also the firing of the guns, could be intrusted to such volunteers, and the pure navigation of the ships and boat-work done by men of whom there are so many around our coasts as trawlers, fishermen, and others. I suggest that the whole of our coasts could be defended by torpedo boats and destroyers, leaving the battleships to do their work on the high seas.

It has been said that the war in the Far East has proved the utility of the battleship, and that only. But it must be remembered that Admiral Togo had to nurse his destroyers and do the greatest injury with the smallest risk, so that had he had more destroyers, and so been enabled to risk more, we might have heard a different account of the deadly weapon, the Whitehead.

At all events, I think that, say, 1,200 men would be better utilized in craft of the destroyer and torpedo-boat description than putting the same number in a large battleship, which might be sunk by even one of these craft; and we have very high authority stating that four such craft, costing a fourth the price, and manned by a fourth of the crew of a battleship, would doubtless sink that battleship. And surely they would prevent her approach to our shores near enough for her guns to range us. Moreover, torpedo boats and destroyers remain war-worthy longer than battleships.

In these days, when conscription is being preached, it is well to consider alternatives. Our thickly-inhabited islands have 3,740 miles of coast line. Allowing one destroyer or sea-going torpedo boat to each ten miles, we find that 200 destroyers and 174 torpedo boats, manned by twenty-one thousand sea-stomached young mechanical engineers and small-craft men, would give national mental repose at a cost of twenty millions sterling as a preliminary outlay and about two millions a year for wages and maintenance.

Is this as good as conscription? Would not young Britons prefer to serve in and be slaughtered in a destroyer rather than a battleship? Indirectly, our nation should gain by the technical education imbibed, both in constructing this Ban Dog fleet and also in service therein. "'Ware the Ban Dog," so long potent in our island life, would suggest a motto for such a corps—W. T. B. D

A SURVEY OF SCOTCH SHIPBUILDING IN 1905.

BY BENJAMIN TAYLOR.

When reporting to MARINE ENGINEERING a year ago on shipbuilding in Scotland in 1904, I said that while that had not been a record year the output of the Scotch yards had turned out greater than was anticipated. The output of 1905 has, however, been a record. It amounted to 587,930 tons, and is one-third of the production of the United Kingdom, and one-fifth of the estimated production of the world. It has not been a year of any remarkable sensation in shipbuilding, although the yards have yielded some monsters, but it has been a year of striking developments which merit some consideration here.

In the world's output the lead is still held by the United Kingdom. There have been increases of output in most of the shipbuilding countries of the world, but the increase in the United Kingdom is most marked. British yards in 1905 built, in excess of 1904, 112 vessels of 429,838 tons and 162,887 indicated horsepower. This addition is more than the whole production of either Germany or the United States, and yet the yards were not operated up to their full capacity. In time of real pressure they could add as much to the 1905 output as they that year added to the output of 1904. There were increases on the Tyne, the Wear, the Tees, and Hartlepool, Barrow-in-Furness, the Humber, and the English Channel; in the United States, Germany, Holland, Japan, Russia, Denmark, Sweden and Spain; but there were decreases on the Thames, the Bristol Channel, and in France, Italy, Norway, Austria-Hungary, China, and Belgium.

The Clyde has for the third time launched within twelve months an aggregate of over half a million tons. Prior to 1901 the annual figures ran generally between 300,000 and 400,000 tons. After the depression of the "eighties" shipbuilding made steady progress, always gaining more ground than it lost. In 1901 the half-million ton mark was turned; in 1902 there was further progress; in 1903 and 1904 dull trade gave the figures a set-back; but now the lost ground has been more than regained. In 1905 310 vessels of 539,850 tons were launched here, 121,980 tons more than the output of 1904, and 22,873 tons more than that of 1902, the previous record year. Russell & Company, Port-Glasgow, are again the builders of the largest tonnage on the Clyde for the year. In 1904 they were highest, not only on the Clyde, but in the whole world. After them on the Clyde come Charles Connell & Co. Barclay, Curle & Co., Limited, who were third in 1904, are now fourth, and the Fairfield Company are now third. D. & W. Henderson & Co. have a larger tonnage than they had last year, and are fifth.

Among vessels built on the Clyde in 1905 precedence must certainly be given to the Cunard turbine steamer *Carmania*,* which was the largest vessel launched on the river, and the most interesting launched in the world. Other turbine steamers launched on the Clyde were the *Maheno*† at Dumbarton, for New Zealand; the *Dieppe*** at Fairfield and the *Onward* and *Invicta* at Dumbarton,—all three for English Channel service. Other large vessels were the Fairfield Canadian Pacific steamer *Empress of Britain*††, the Hamburg-American liner *Fuerst Bismarck*, also built at Fairfield; three P. & O. liners built at Caird & Co's, and the two P. & O. liners *Dongola*§ and *Peshawur* built at Barclay, Curle & Co's. Only one warship is in the list of Clyde launches, H. M. S. *Cochrane*§§, built at Fairfield. In all the 319 launches there was only one sailing vessel, though in 1904 half a dozen sailers were included. The following table shows the types of vessels which compose the Clyde tonnage of 1905:

TYPE	NO.	TONNAGE	MEAN
Screw steamers	165	389,064	2,358
Twin screw steamers	21	76,648	3,650
Turbines	5	29,444	5,889
Warships	1	13,550	13,550
Dredgers	25	12,851	514
Barges and lighters	30	6,863	229
Paddle steamers	14	2,656	190
Sailing vessels	1	2,430	2,430
Fishing vessels	12	2,356	196
Tugs	19	1,935	102
Yachts	14	1,050	75
Sternwheel steamers	9	968	108
Launches	3	35	12
	319	539,850	1,693

While in 1904 the Clyde produced five of the six largest vessels built in the world, in 1905 the Clyde has only three of the largest. Harland & Wolff, Belfast, had two, and the Vulcan Company of Stettin had one. Two Hamburg-American liners exceeded in size the *Carmania*. The 1904 average of large vessels was 11,769 tons for six vessels; in 1905 the average was 18,000. The leading vessels built in Europe, measured by tonnage, and excluding warships, are:

VESSEL	GROSS TONS	BUILDERS
Kaiserin Auguste Victoria	25,000	Vulcan Co., Stettin
Amerika†	22,724	Harland & Wolff, Belfast
Carmania	19,594	John Brown & Co., Clyde
Nieuw Amsterdam	17,250	Harland & Wolff, Belfast
Empress of Britain	14,530	Fairfield S. & E. Co., Clyde
Mooltan	9,621	Caird & Co., Clyde

There were fewer turbine vessels launched in 1905 than in 1904, but there are a large number now on order. The 1905 turbines are:

VESSEL	GROSS TONS	BUILT AT	FOR
Dieppe	1,217	Govan, Clyde	Newhaven
Maheno	5,282	Dumbarton, Clyde	New Zealand
Onward	1,671	Dumbarton, Clyde	London
Invicta	1,680	Dumbarton, Clyde	London
Carmania	19,594	Clydebank, Clyde	Cunard Company
Viking	1,951	Newcastle, Tyne	Isle of Man
Bingera	2,000	Belfast	Glasgow
Kaiser	1,916	Stettin	Hamburg

The Allan turbine liner *Virginian** was the first of the ocean-going turbine steamers—length 540 feet, and 13,000 tons displacement, equivalent horsepower 12,000, with three shafts running at 275 revolutions. The trial speed was 19.5 knots. This ship was built by Workman, Clark & Co., Belfast, and her sister the *Victorian*, by A. Stephen & Sons, Clyde. H. M. S. *Amethyst*§, a turbine cruiser of the British Navy, 360 feet long and 3,000 tons displacement, was built in 1904 and delivered in 1905. She was the immediate cause of the Admiralty's adopting the Parsons turbine for all the designs issued during 1905. Built by the Armstrong Company, on her full power trial she ran at 23.6 knots, as against 22 knots of her sister ship *Topaze*, showing that with the same steam capacity turbines can exert a power 40 percent greater than reciprocating machinery. The Clyde steamers *King Edward*** and *Queen Alexandra* of 1901 and 1902, were the pioneers of turbine passenger steamers, and now there is a long list of fast channel steamers using the Parsons turbine; but

*See page 1, MARINE ENGINEERING, January, 1906.
†See page 489, MARINE ENGINEERING, December, 1905.
**See page 247, MARINE ENGINEERING, June, 1905.
††See page 16, MARINE ENGINEERING, January, 1906.
§See page 46, MARINE ENGINEERING, February, 1906.
§§See page 295, MARINE ENGINEERING, July, 1905.

†See page 483, MARINE ENGINEERING, December, 1905.
*See page 359, MARINE ENGINEERING, September, 1905.
§See page 37, MARINE ENGINEERING, January, 1905.
**See page 395, MARINE ENGINEERING, September, 1901; also page 8, January, 1902.

uncertainty has existed as to the power likely to be developed, and the speed to be realized.

The *Viking**, on the service between the Isle of Man and Liverpool, was built by the Armstrong-Whitworth Co., for the Isle of Man Steam Packet Company. The service speed guaranteed was 22 knots, and on her trial the ship ran for 140 miles at a mean speed of 23.5 knots. She is 361 feet long and 42 feet broad, with a shelter deck and a long promenade deck to accommodate an enormous number of passengers.

The turbine yacht *Albion* was designed by Sir William H. White for Sir George Newnes, and was built by Swan, Hunter & Wigham Richardson, Tyne. She is 270 feet long, 34 feet beam, and of 1,250 tons (Thames Yacht measurement). Her speed is 15 knots, for which turbine machinery of 1,800 equivalent horsepower is provided, there being three screws, one on each shaft. She carries enough coal to go around the world under her own steam. All the auxiliary machinery is worked by electricity, and she is as free from vibration as a sailing vessel.

The *Carmania* has been already fully described in these pages. Her dimensions are 650 feet length, 72 feet breadth, 33 feet 3 inches draught for 30,918 tons displacement. She was built to Admiralty requirements as to subdivision and protection under water of her steering gear and rudder, and is liable to be taken up by the government as an auxiliary cruiser. Her main interest is the adoption of Parsons' turbine machinery, being fully a knot faster than her sister ship *Caronia*, fitted with reciprocating machinery. The *Carmania*, with a foul bottom, realized on her trial trip 20 knots, and with a clean bottom is good for 20.5 knots, a speed more than the owners required.

The *Empress of Britain* and her sister ship *Empress of Ireland* are the latest ship enterprises of the Canadian Pacific Railway Company. These splendid passenger steamers are to run between Liverpool and Quebec. The dimensions are: 570 feet over all, 65 feet 6 inches breadth; gross tonnage, 14,500; displacement about 20,000 tons. The ships are held by some to represent the last word of the marine engineer in respect to reciprocating machinery for Atlantic liners. On their regular service they are expected to do the trip in a week. Each ship will carry 310 first-class, 470 second-class, 500 third-class passengers, on or above the main deck, and 270 steerage passengers on the lower deck forward. The builders are the Fairfield Company, Glasgow.

Shipbuilding designs are changing faster than they did formerly, and ships now become obsolete more frequently by getting out of date than by age. The building of single deck cargo steamers displaces vessels of older types while the intermediate liner carrying passengers with a large amount of cargo is affecting the purely cargo steamer. The cargo boat must, therefore, be specialized in every possible way. In grain, ore and coal carriers the design is to facilitate loading and discharging, and the necessity for quick dispatch has evolved the self-trimmer and the beamless turret. As these types come in the older types are sold to foreigners, and this process of conversion accounts for a large proportion of the recent boom. It is commonly said that the day of the sailing ship is coming to an end, but in certain trades the big sailer will hold her own. Still, the building of sailing ships was certainly never at a lower point, and even in France, in spite of bounties, there is now hardly anything built but steamers.

An interesting type of cargo vessel is the *Christian Knudsen*, launched during the past year by Sir Raylton Dixon & Co., of Middlesborough. She is built with holds free from any obstructions of beams, pillars, web frames or side stringers, by the use of cantilever framing, and top-side water-ballast tanks. The hold is thus adapted to the self-trimming of cargo without loss of stowage. The tanks under the deck are employed for ballast, together with the double bottom, and proper immersion is given for seaworthiness. She behaves well at sea, not shipping any water even in the heaviest weather on the Atlantic. She has large hatchways, 70 feet by 30 feet, and carries nearly 7,000 tons of coal, which can be discharged in seven hours without any "trimmers."

The conditions of shipowning make now for standardization, as builders' records show. Standardization was in evidence when sailers were being turned out rapidly; and among builders of trawlers standardization has been constant for some time. The standards now in evidence are:-Spar deck, 344 feet by 49 feet by 17 feet 9 inches; also 330 feet 9 inches by 45 feet 6 inches, by 16 feet 2 inches; and of both of these quite a number of vessels have been built. Single deck steamer types are 340 feet by 48 feet by 25 feet 9 inches; and 331 feet by 47 feet by 24 feet 8 inches, of both of which also a large number has been built. The size has been increasing, and single-deck steamers 345 feet by 49 feet 9 inches by 28 feet 5 inches have recently been favorites; also a larger type, 370 feet by 49 feet 9 inches by 29 feet 8 inches. Some owners, for the same length, have two feet more beam and a foot less depth, giving a vessel capable of lifting 7,100 tons on a draft of 22 feet 6 inches. Of these standard types nearly 150 steamers have been built in the Scottish and English yards. This refers to tramps, but standardization is adopted in other branches of structural engineering, and it would seem that the yards that standardize most are the yards that will do the most business.

The case of Wm. Doxford & Sons, Limited, is one in point. The year 1905 has been a record year on the Wear, and to this result the above firm have materially contributed. During the course of the year they launched twenty of their "turret" steamers of a total of 86,632 tons. They are not only first on the Wear list, but they have this year the largest tonnage for any single firm in the world. Three of the largest "turret" steamers in the world—vessels of 7,700 tons register—are among their products. Messrs. Doxfords' success must be attributed to standardization,—to specialization in a type that is economical in structure, in working and in carrying capacity.

The building of steam trawlers is another specialty in which standardization tells. These vessels are turned out in large numbers at Hull, Yarmouth, North and South Shields, Aberdeen and Glasgow by firms who specialize in this class of work. The conversion of the fleets of sail fishing boats into trawlers, drifters and fleeters has given a great deal of work to these builders, and new markets for steam fishing vessels are being found. Newfoundland, South Africa, and Australia are all developing their fisheries by acquiring steam trawlers of large size and good speed, and various British firms have executed contracts for these colonies. Several large trawlers have been built by Mackie & Thompson, Glasgow, for French owners; while Smith's Dock Company, North Shields, have built four large trawlers for French owners for use on the Newfoundland coast. The John Duthie Company, Aberdeen, have built a trawler of 300 tons, also for France.

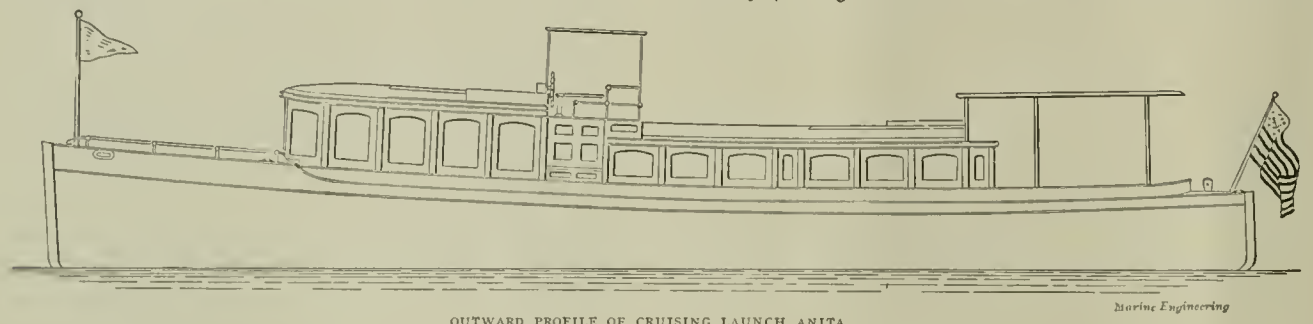
The reciprocating engine has been practically abandoned for certain classes of ships, and engineers are now turning fresh attention to the boiler, and even dream of a turbine ship without boilers. The gas turbine may bring this within the range of practical engineering.

The use of the petrol (gasoline) engine for marine work is increasing, and for certain work there is an enormous field for it. The gas engine with plant for producer gas is in operation for land work up to 5,000 indicated horsepower; but there are certain disadvantages in its use for large marine work, such as lack of easily worked reversing power. Sir William White said recently at the Motor Show at the Crystal Palace, London, that "taking the latest types of steam machines and comparing them with the explosion engine, the internal combustion motor and its fuel gives equal speed and equal range of action to a steam engine—with boiler, water and fuel of six times the weight." The question is whether the explosive engine of the motor car

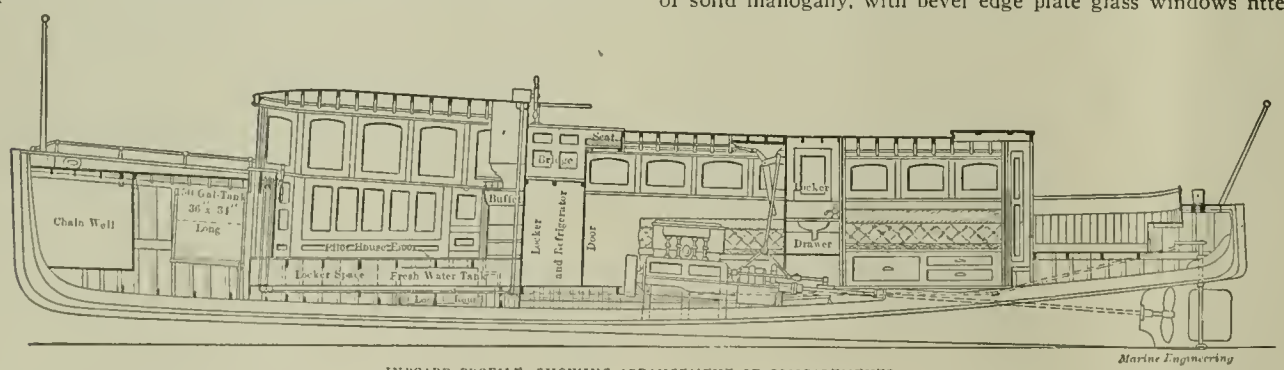
*See page 443, Marine Engineering, November, 1905.

contains within itself the germ of the power to propel ships better than they are at present propelled by steam. Engineers are looking towards the gas motor as the germ of the engine of the future. Already Thornycroft & Co. have turned out a gas-producer motor boat, which has run trials at Southampton. William Beardmore & Company, Clyde, have the British rights in the Capitaine gas engine, and they are re-engining a steamer, *The Earl,* by substituting for the boiler and reciprocating engine a Capitaine gas engine, intended to develop 600 horsepower. The result of this experiment will be looked forward to with great interest.

The motor boat *Napier Major* was the center of attraction at the recent motor exhibition in London. Her dimensions are 45 feet by 8 feet 6 inches by 5 feet 6 inches depth. Her engine is a 24 horsepower 4-cylinder Napier, giving a speed of about 8 knots. She is a fine sea boat, and is rigged so that in case of necessity she could sail into port. Seven people can be accommodated on board. She has traversed 6,000 miles of sea in six months and performed a non-stop run of 650 miles in 5 days and nights. The *Iris,* of Southampton, 30 feet in length, was run from Southampton to Gravesend without a stop. In fact the day of the motor boat has come; and we now await the advent of the gas-producing self-propelling motor ship for ocean carrying purposes.



OUTWARD PROFILE OF CRUISING LAUNCH ANITA.



INBOARD PROFILE, SHOWING ARRANGEMENT OF COMPARTMENTS.

THE FIFTY-ONE FOOT CRUISING LAUNCH ANITA.

The launch of which we present illustrations has been built by the Matthews Boat Company, of Bascom, Ohio. The length over all is 51 feet 1½ inches; the extreme beam, 10 feet 4 inches; extreme draft, 34 inches, and freeboard forward 3 feet 2½ inches. In general arrangement, the length is divided into a forward deck, 10 feet in length, a pilot house 11 feet 4 inches, a cabin consisting of an extension aft of the pilot house and with a length of 18 feet 9 inches, and a short open cockpit at the rear. The pilot house is fitted with two pullman berths with a width of about 36 inches, the interior finish of the entire house being raised panel work in mahogany. This pilot house has further a folding mahogany table and a staircase leading to the bridge, which is situated immediately abaft of the pilot house on top of the forward end of the cabin. There are also a mahogany buffet and wardrobe with plate glass panels and suitable arrangement of drawers, lockers, etc.

The engine room is in the forward part of the cabin, and is furnished in the same manner as the pilot house, having on the port side a sliding berth for the engineer and on the starboard side pullman folding berths. Under these is space for lockers and cupboards for stowage of supplies. The galley is fitted with a kerosene stove and a sink, together with a fresh water tank in the floor with a capacity of sixty gallons and connected with a nickel plated pump; a zinc-lined refrigerator, dish rack and glass rack, and a ventilator in the roof to carry off the odor of the cooking. The floor is covered with linoleum, and all the hardware is of polished brass. A toilet room and lavatory is fitted just aft of the engine room, and measures 2 feet 6 inches by 4 feet 5 inches.

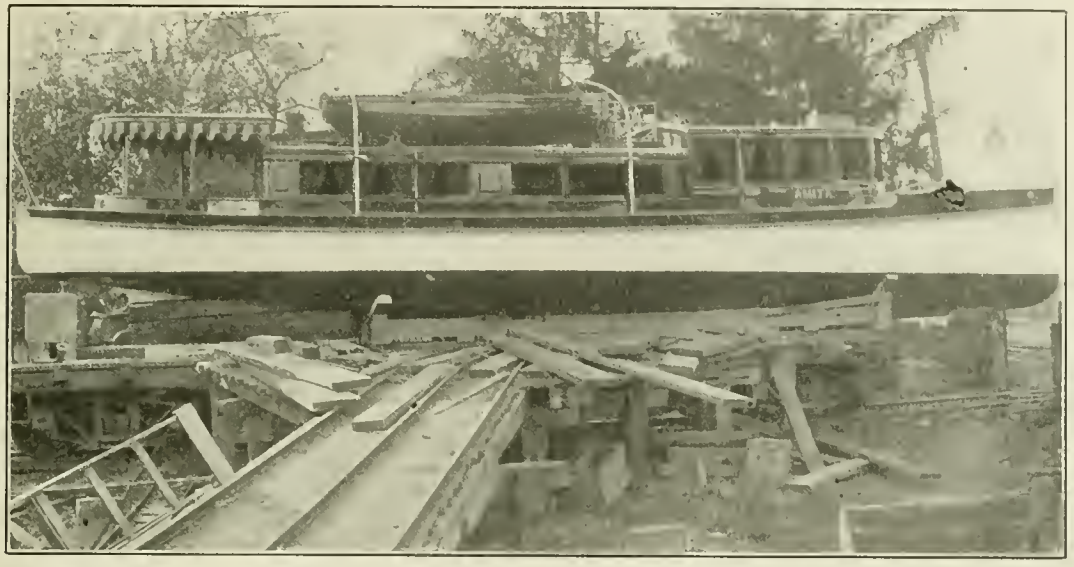
The after part of the cabin is fitted with broad davenports on each side, being of an extension berth pattern 36½ inches in and cupboards for stowage of supplies. The galley is fitted on each side one large and two small drawers. At the rear end are full length wardrobes fitted with shelves and brass hooks. A sliding hatch in the companionway affords exit from the cabin to the rear cockpit. The latter is open, with a stationary canopy top supported by turned stanchions, and is finished inside and out with solid mahogany, together with a mahogany coaming; the floor covering is of inlaid linoleum, and cushions of fabrikoid cork. The finish throughout the cabin both inside and out is of solid mahogany, with bevel edge plate glass windows fitted to drop into pockets, and with brass locks and lifts. The windows of the pilot house and saloon are fitted with curtains matching in general coloring the upholstering, and the floors are covered with wilton carpets of the same general color scheme.

The construction of the hull includes keel timbers of white oak 2⅞ inches thick, in widths of from 12 to 19 inches, all joints being laid in white lead and fastened with bronze bolts; the scarfs or joints have a length in each case of not less than 54 inches. There are sister keelsons bolted to the keel, and constructed of white oak 2¼ by 5¼ inches, with proper notches to receive the ends of frames, the main keel being rabbetted to receive the outside planking. The shaft log is of white oak 6 by 8 inches in section. The frames are of white oak 1½ by 1¾ inches, steam bent, and spaced 9 inches between centers except over the 12 feet of the engine compartment, where the spacing is 5 inches. Sheer strake is of mahogany 1⅜ inches thick and varying in width from 5 to 7 inches. A mahogany bulwark is fitted on the forward deck, 7¼ inches high at the stem and 8½

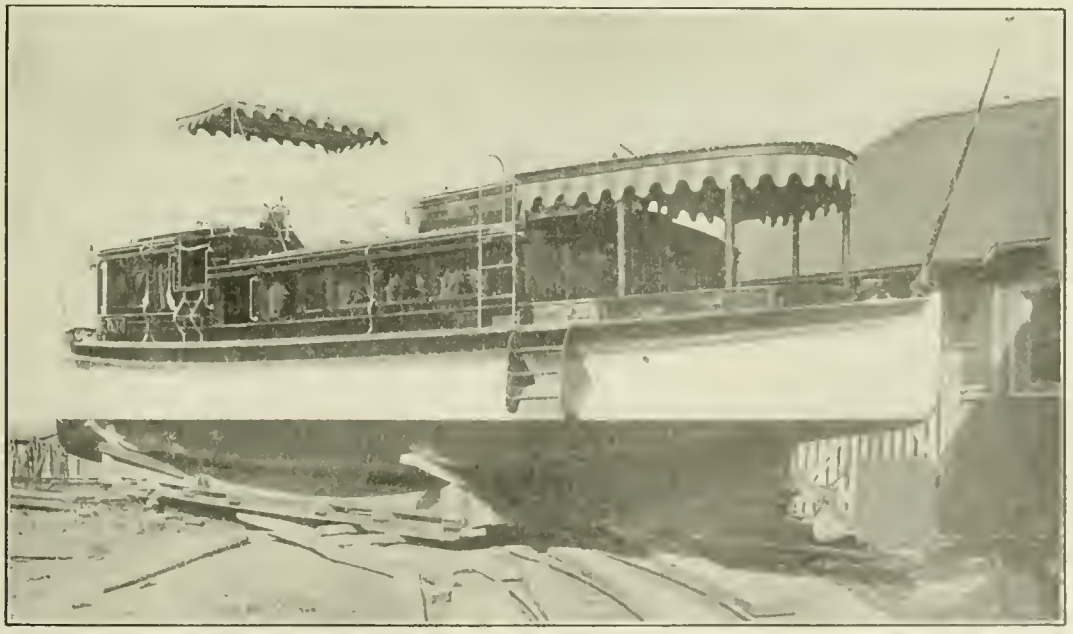
inches above the deck at the rear end, the length being 14 feet. These measurements include the height of the rail, which is of white oak 3½ inches wide and 1¼ thick. The bulwark is supported by heavy oak extensions to the frames. The deck is of white oak fitted in strips 1 by 1¾ inches, with seams thoroughly calked. The outside planking is of cedar, tapering in thickness from 1¾ inches at the garboard strake to 1⅜ at the sheer, the garboard strake itself being of white oak 1¾ inches thick. All the planking is secured to the frames by riveted copper nails, all butts being reinforced with white oak blocks. The engine timbers measure 3 by 7 inches in section and are 14 feet long, extending fore and aft on either side of the keel and securely fastened to same; thwartship oak timbers 3 inches thick being fitted to support the engine. The engine and fly wheel pits are lined with sheet brass for the purpose of excluding water and collecting oil.

A gasoline tank is fitted forward under the open deck, with a capacity of 150 gallons. It is constructed of heavy rolled copper, copper riveted, and is suitably provided with ventilating device. The pipe leading to the engine is of seamless brass tubing, with all joints threaded and then tinned. It runs inside the hull, passing through the water tight bulkhead at the forward end of the pilot house. There is also provided under the forward deck a chain locker with suitable hawser pipe on deck and a small horizontal capstan operated by hand. Two steering wheels are provided, one being a large mahogany wheel with brass trimmings in the pilot house, and fitted in a handsome binnacle stand, while the other, which is of solid brass, is located on the bridge, and has a diameter of 21 inches. The steering cable of phosphor bronze, which passes through suitable blocks and guides, has a diameter of ⅜ inch. The tiller is of bronze of a compensating arc type with rudder and rudder post of tobin bronze. A skeg of this same material, measuring 1⅛ by 2 inches, supports the lower end of the rudder post.

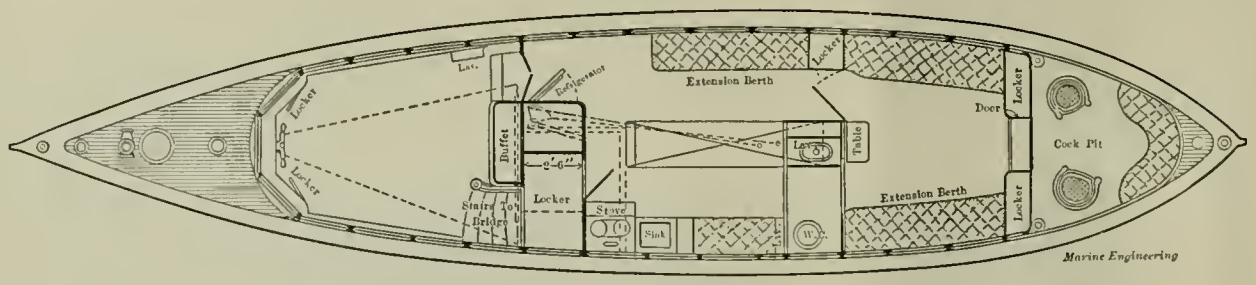
There are fitted a small Carlisle-Finch searchlight, with a dynamo connected to the engine, and storage batteries for use when the engine is not running. Electric lights are fitted



STARBOARD SIDE OF ANITA, READY FOR SHIPMENT.



QUARTER STERN VIEW, SHOWING THREE-BLADED PROPELLER.

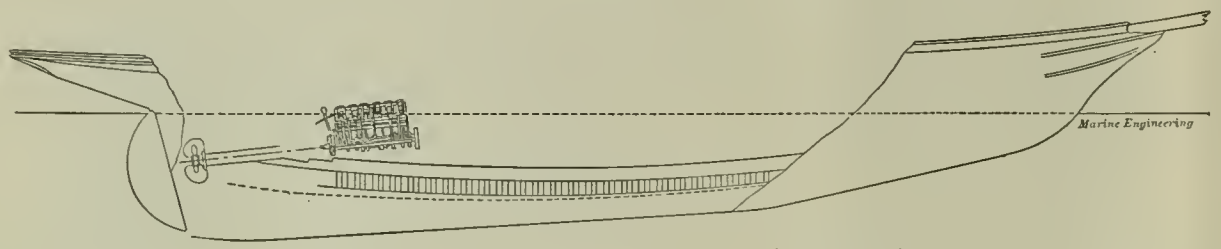


GENERAL ARRANGEMENT PLAN OF LAUNCH ANITA.

throughout the hull, there being one ceiling fixture and one wall fixture in the pilot house, with opal globes; a wall fixture and a switchboard fixture in the engine room; lamps in galleys and toilet room; a ceiling fixture and two side wall fixtures in the saloon.

An Auxiliary Fishing Schooner.

The largest fishing schooner on the New England coast is the *Elizabeth Silsbee*, of which we are enabled to present herewith photograph and sail plan, as well as a photograph of the engine and view showing its position in the ship. The *Silsbee*

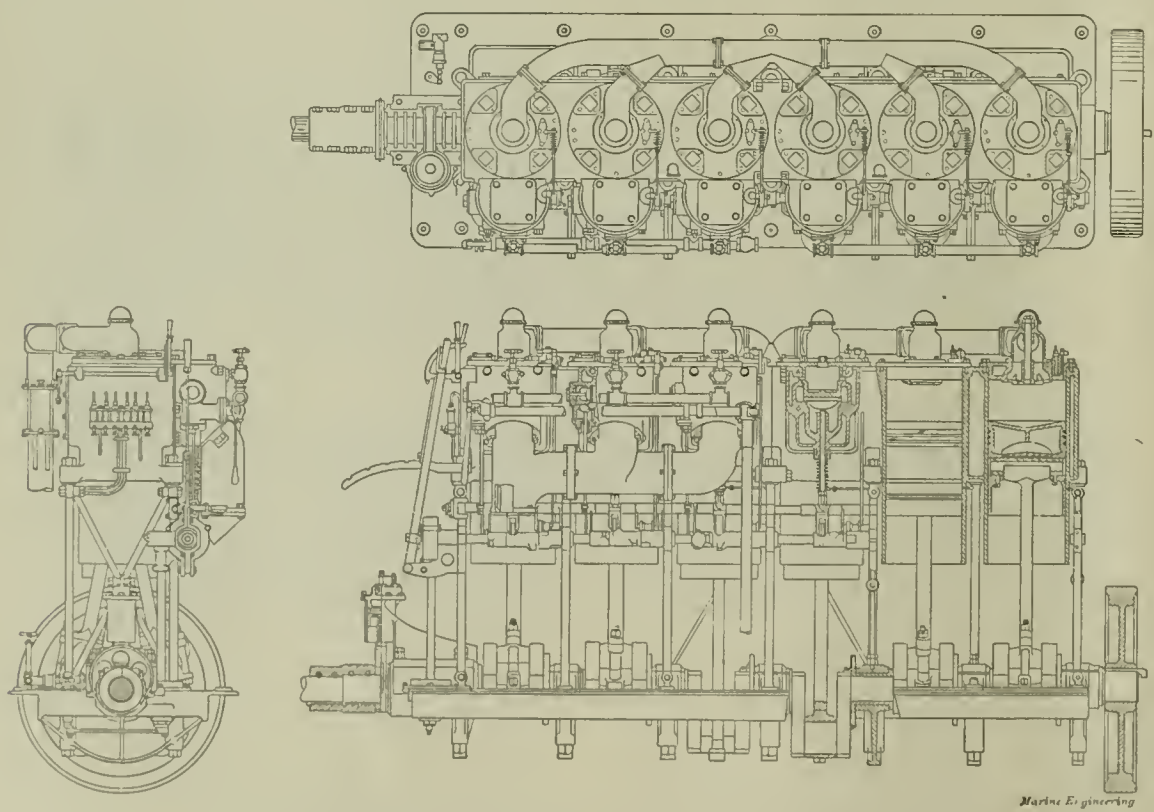


SKETCH OF SILSBEE, SHOWING LOCATION OF 300-HORSEPOWER ENGINE.

The equipment further provides a pair of galvanized steel davits and blocks for hoisting the anchors; a pair of boarding steps: the usual flagpoles and ropes; fenders; buoys and lines; and an anchor weighing 100 pounds, with 160 feet of rope. There have also been provided a mahogany finished 12-foot yacht tender for propulsion by oars, and appropriate galvanized steel davits with lignum vitæ blocks for hoisting the tender to the roof of the cabin.

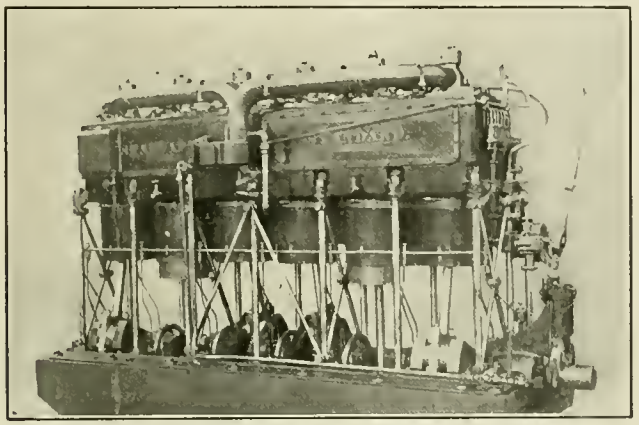
has a length of 134 feet over all, 103 feet on the water line, a beam of 25 feet and a draft 13 feet 6 inches. The bowsprit has a length of 32 feet outboard, the foremast and mainmast heights above deck of 65 and 77 feet respectively, the fore and main topmasts lengths of 45 and 52 feet, the main boom 75 feet and the main gaff 50 feet. The dimensions of the several sails are well shown in the sail plan presented.

The schooner has been fitted with a 300-horsepower gasoline



PLAN AND ELEVATIONS OF 300-HORSEPOWER STANDARD ENGINE, AS FITTED TO ELIZABETH SILSBEE.

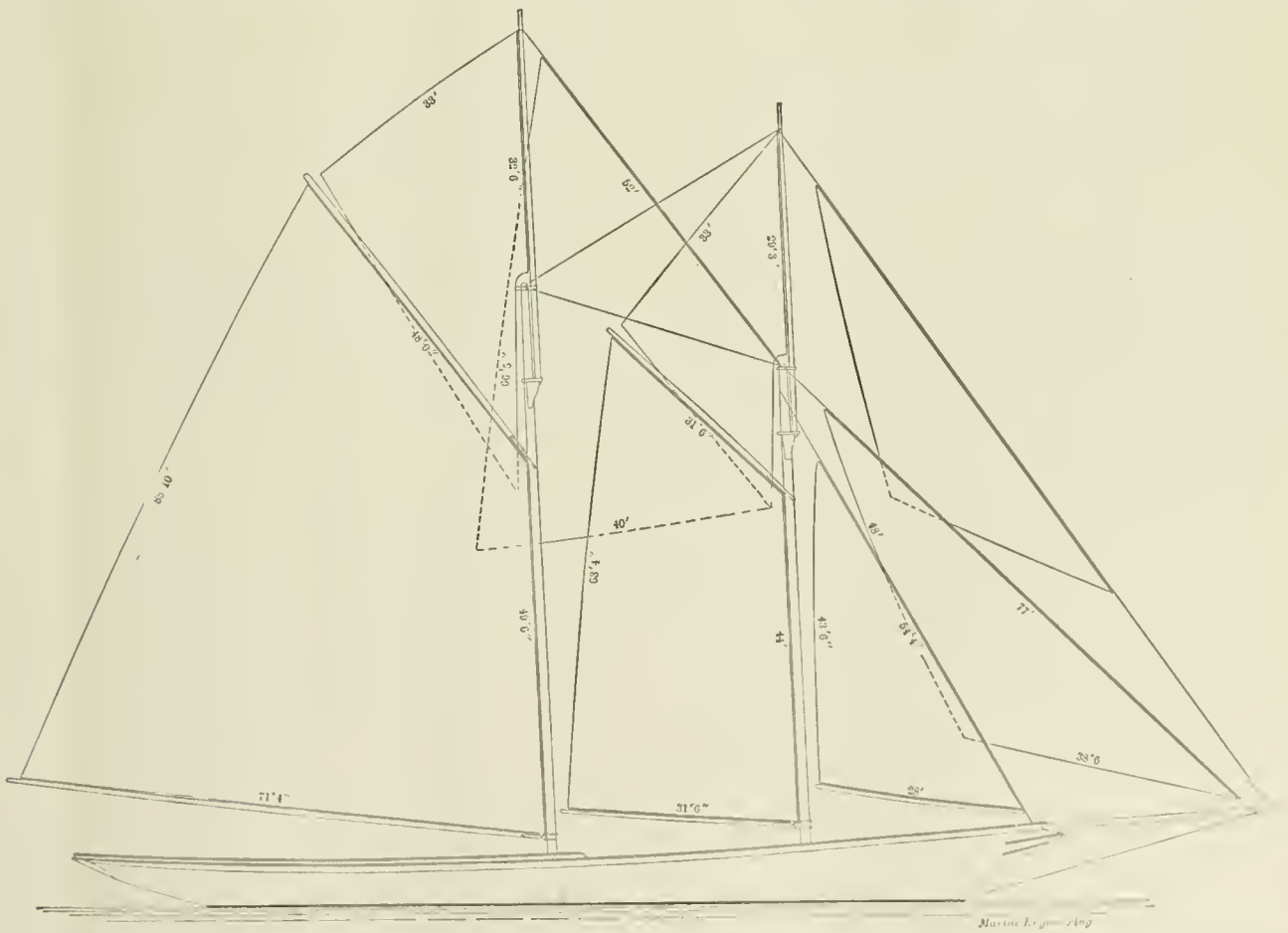
engine of the reversing type, built by the Standard Motor Construction Company of Jersey City, and having six cylinders measuring 12 inches diameter by 14 inches stroke. The reverse arrangement is said to be as positive as the reversing gear on a steam outfit. The propeller is coupled direct to the engine and



REVERSING ENGINE OF SILSBEE.

THE SILSBEE UNDER SAIL.

is started instantly by shifting the valve motion to the desired position, there being no dead centers. The reversing mechanism is not of the haphazard type in which the operation is obtained by advancing the spark and tripping same to cause the engine to kick back, but is of such a nature that it can be started over smoothly, the air supply is shut off and recourse had to power derived from the gasoline in the regular way. The air tank is of sufficient capacity to cover twenty or thirty starts,



SAIL PLAN OF AUXILIARY FISHING SCHOONER ELIZABETH SILSBEE.

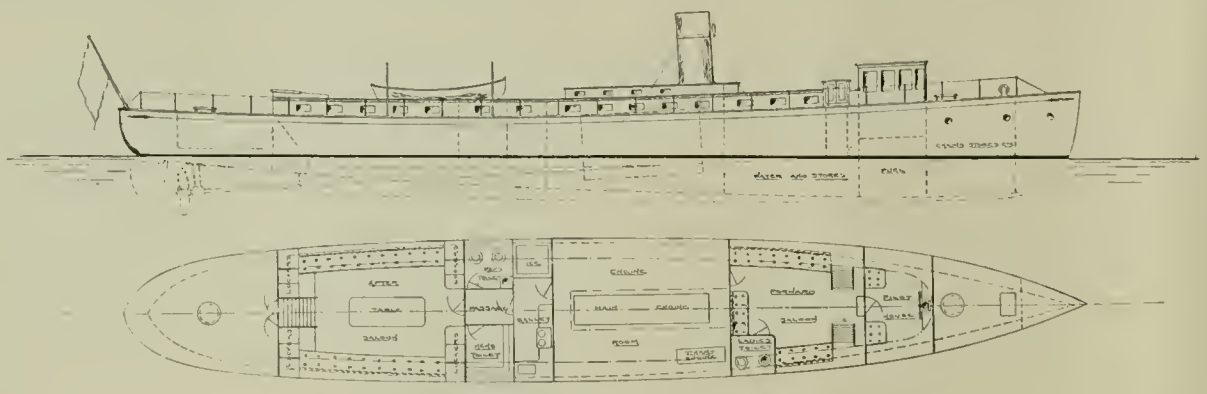
from a cold engine. The valve motion is shifted from a central point to the forward or reverse position, and the engine started by means of compressed air. As soon as the engine is turning and is kept replenished by a small air pump attached to the engine.

The *Silsbee* is stated to be not only the fastest fishing schooner

under sail, but also the fastest under power. With the machinery fitted she has no difficulty in making twelve knots, and when to the power of the engine is added a good whole sail breeze, it is not unusual for her to reel off sixteen knots for hours at a time. Two or three more boats of the same type are under construction. We are indebted for information regarding the *Silsbee* to Burgess & Packard of Boston, who superintended her refit.

A NEW MOTOR FISHING BOAT.

The accompanying cuts show the general arrangement and lines of a motor boat, being built at the works of the Electric Launch Co. of Bayonne, N. J., from the designs of N. C. Cushing, of New Rochelle, N. Y. The boat is intended for carrying fishing parties on daily excursions to various points along the New Jersey coast. The maximum carrying capacity is to be one hundred passengers, and the speed is to be 18 miles per hour. There are consequently no sleeping accommodations for passengers and the hull is so designed that speed, seaworthiness and carrying capacity have been given like consideration. The flare of the fore body should keep the boat very dry in a head sea, and the stern is so formed that the boat will lie easily in a following sea.



PROFILE AND ACCOMMODATION PLAN OF MOTOR FISHING BOAT.

The underbody is cut away in as easy a line as possible from stem to stern, to assist the speed, but the lines are kept very full aft to prevent squatting as much as possible when under full speed. The dead wood is carried well aft to insure the boat steering easily in a following sea, and in addition it lessens the rolling tendency and protects the shafting.

The engine is to be a six-cylinder, double-acting motor of 500 horsepower, of the latest type, built by the Standard Motor Construction Co. of Jersey City.

This is the highest powered single gas engine ever put into a boat, and is sufficient to give the five feet diameter propeller three hundred revolutions per minute. The exhaust will be carried up through the stack, which is shown on the plan.

The arrangement of the boat is very simple but sufficient in every way to satisfy the comfort of the passengers. The after saloon is 19 feet long, with a large centre table, and settees along either side. At the forward and aft ends of this saloon are 48 lockers for the storing of fish baskets and gear. Forward of the saloon, on either side of the passage leading into the galley, are the men's toilets. The galley extends for the full width of the boat, and is fitted with stove, sink, ice-box and the necessary shelves and lockers.

Forward of the galley is the large and airy engine room, 18½ feet long, containing the main engine, pumps, air-starting tanks and the dynamo, which is to furnish electric lights to all parts of the boat. The berths for the engineers will be situated on the port side of the engine room.

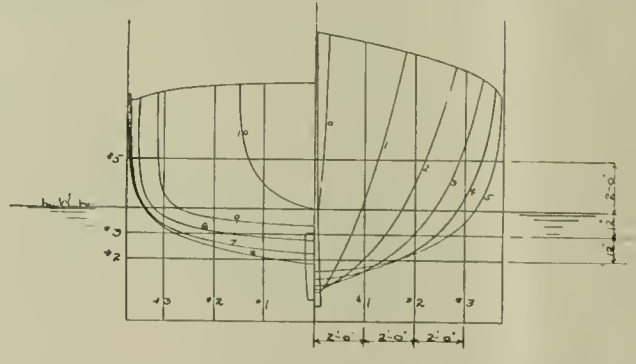
Directly forward of the engine room is the forward saloon, 14 feet long, with settees on either side, and the ladies' toilet on the starboard side in the after end. In the forward end on either side of the saloon is a companion leading up to the main deck. The pilot house, which is 7 feet in length, is forward of the saloon as shown, and is fitted with steering wheel, compass and overhead chart racks. Forward of the pilot house and below the main deck is the electric windlass for handling the anchor. The anchor chains and other stores will also be in this compartment, which is entered by a hatch in the main deck.

The tanks for the fuel will be under the pilot house, and those for water will be under the forward saloon. There will be one thousand gallons capacity of fuel, and five hundred gallons capacity for water, in the tanks.

The trunk of the cabin is 20 inches high and is 24 inches in from the side of the boat. These dimensions are to enable the passengers to sit comfortably on the trunk and fish over the hand rail, which extends all fore and aft.

The keel is of white oak, and is tapered in width at the bottom from 6 inches at the foot of the stem to 8½ inches at the after end. The frames will be of white oak 2½ inches by 3 inches and will be spaced at 12-inch intervals, and connected at the bottom by oak floors. The beams throughout will be of white oak, those for the main deck being 3 by 1¾ inches, and for the lower deck, 2 by 1½ inches.

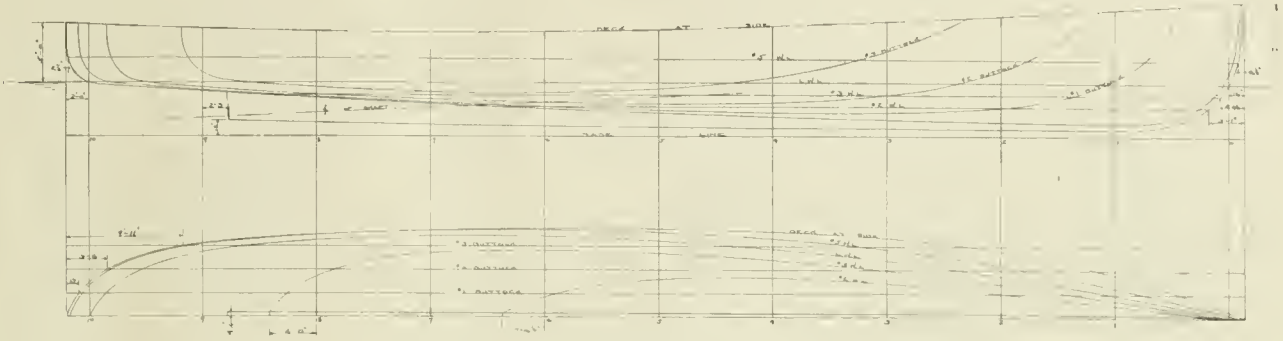
The engine foundation will be of yellow pine and will be formed by two longitudinal built-up girders extending well forward and aft of the engine bed. In addition the floors in way of the engine will be of extra depth and thickness. The bilge stringers on either side will be of yellow pine 4 by 6 inches, and will extend all fore and aft.



THE BODY PLAN

The hull planking throughout will be of yellow pine 1⅛ inches thick. The plankshеer will also be of yellow pine, 6 inches by 2 inches. Directly under the plankshеer and extending the full length of the boat is a fender of white oak 3½ by 3 inches for the protection of the planking in the many dock landings which will have to be made. The main deck will be of white oak 1⅛ inches thick. The sides of the deck house will be white oak, fitted as shown with sliding windows, which will

be protected by brass rods. The pilot house will also be of white oak, and will be raised sufficiently to give the pilot an unobstructed view in every direction. The lower deck will be white pine 7/8 inch thick, tongue and groove. There will be five watertight bulkheads of 1¾ inches white pine.



WATRR LINES, AND BOW AND BUTTOCK LINES OF MOTOR FISHING BOAT.

The boat will be equipped with a life raft, boats, life preservers and all other fittings which can in any way promote the comfort and safety of the passengers. The boat is to be delivered in May in order to be in service during the coming season.

Speed of Sailing Vessels

Editor, Marine Engineering:—

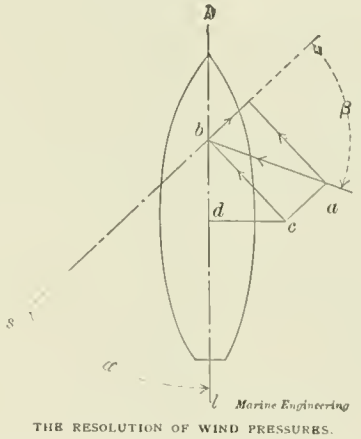
Do sailing vessels sail faster than the velocity of the wind propelling them?

Several months ago there appeared in the New York *Times* an article in which, among other things, was explained how a boat could, and often did, sail faster than the wind propelling it. The explanation given was substantially as follows: If a ball is placed on a billiard table and is urged forward with the cue, it will be seen that the ball travels at the same rate as the cue, but if a groove is cut in the table diagonally, so that the ball is forced to travel in it, then when the cue is moved across the table as before, the ball will travel much faster than the cue, and this is what occurs in the sail boat.

It would seem that there is a very apparent fallacy in this explanation, in that the magnitude of the forces required to move the ball in the two cases is entirely neglected. This brings us to the question: Do sailing vessels ever move faster than the wind propelling them? The answer seems to the writer to be *no,* under *any* circumstances. The result is apparent when looked at from a mathematical or from a common sense point of view.

Considering first the latter view. What makes the boat move through the water? It is the pressure of the wind on the sails. Now the wind's pressure is a direct result of its velocity, and the moving of a vessel in one direction or another, with relation to the wind, does not change the latter's velocity, and hence does not increase its force. It is well known that when the speed of a moving body is increased it takes more power to keep it going, whether it be through a system of gearing, of pulleys, or levers. Therefore, since a vessel can get no more force out of the wind than that due to its velocity it cannot sail faster than if floating in the air and traveling at the same speed as the wind. Again, if the vessel travels faster than the wind, we are getting something for nothing, and the result is "perpetual motion."

Now consider the problem from a mathematical standpoint. In this case, let us assume the best possible conditions, that is, with a sail which is perfectly flat. Let *Kl* of the accompanying figure represent the keel of the boat, *sb* the sail, *ab* the direction and magnitude of the wind, α the angle that the sail makes with the keel, and β the angle that the direction of the wind makes with the sail. Then, by resolving the force of the wind into its two components, one parallel and one perpendicular to the sail, we find that the latter, the effective one, $=$ *ab sine* β. But only a portion of this component is instrumental in driving the boat ahead, that represented by $bd = bc \times \sin\alpha = ab \times \sin\beta \times \sin\alpha$. This, it will be seen, is a comparatively small portion of the original force *ab,* when a vessel is sailing as in the figure, or about as explained with the billiard table. The above expression will be seen to be a maximum when both α and $\beta = 90°$, the full force of the wind being then available. When a vessel is sailing across the wind its own velocity slightly augments the force of the wind, for in this case the sail is running against



THE RESOLUTION OF WIND PRESSURES.

the wind. From the above expression it is also seen that as α (and consequently β) diminishes, the value of *bd* diminishes, whereas in the billiard table illustration *bd* should increase. When α and β each $= 45°$ (the position in which some boats work the best) the value of *bd* is only one-half of the total force of the wind.

The deduction made, therefore, from the foregoing is that no sailing vessel ever travels faster than the wind propelling it.

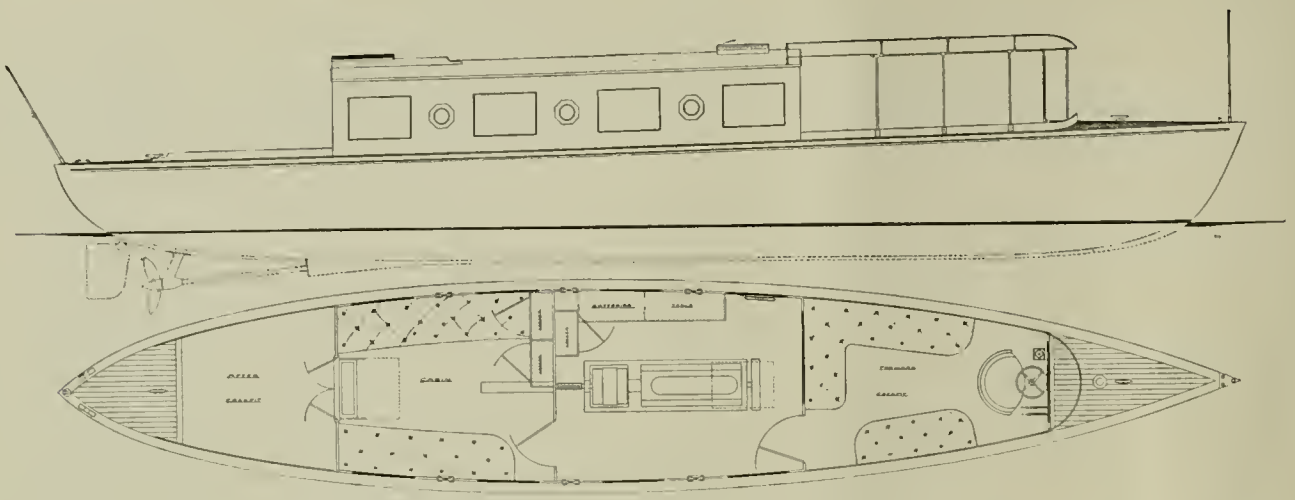
If anyone has made actual measurements to disprove the above conclusions, the result would be most interesting and instructive.

W. S. Fanning.

Obituary.

Capt. John W. Collins, late Engineer-in-Chief of the United States Revenue Cutter Service, died recently at Amityville, Long Island, at the age of sixty-four years. He served under Commodore Farragut at the storming of Fort Fisher, and was on the *Kearsarge* at the time of the fight with the *Alabama.*

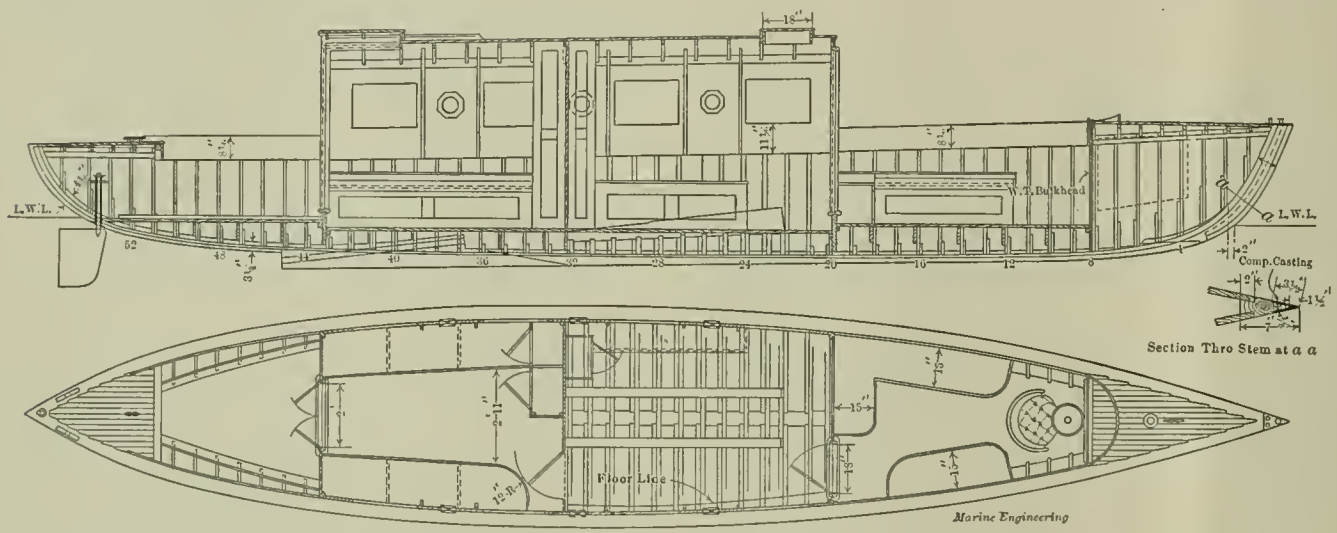
Andrew G. Wilson, manager of the Marine Department of the Maryland Steel Company, at Sparrow's Point, recently died very suddenly at his home in Wilmington, Del. His seven years of service with the Maryland Steel Company were preceded by thirty-six years with the Harlan & Hollingsworth Company.



OUTBOARD PROFILE AND ACCOMMODATION PLAN OF 35-FOOT LAUNCH.

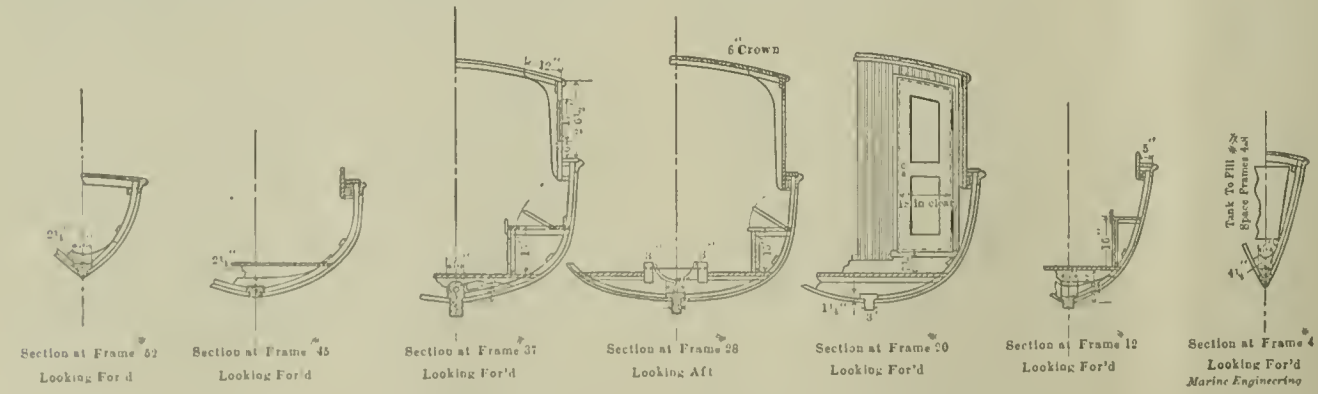
A HALF-CABIN FERRY LAUNCH.

We are enabled to present drawings of a 35-foot launch designed by Messrs. Hoyt and Clark of 17 Battery Place, New York, for use in the sheltered bays along the northern coast of Long Island, as a ferry for going back and forth from house to business. This boat has a length over all of 38 feet 7 inches; length on water line of 35 feet; a water line beam of 6 feet, which becomes 6 feet 9 inches extreme; and has a draft of 1 foot to the base line and 18 inches to the bottom of the keel. The lines as shown in the illustration are drawn to the outside of the planking. A rather unusual feature in this boat is the provision of a forward cockpit, enabling the owner to be out where he can see what is going on ahead, without the necessity of being shut up in the pilot house.



INBOARD PROFILE AND ARRANGEMENT PLAN, SHOWING ENGINE FOUNDATION.

The keel and keelson are of white oak connected with ½-inch galvanized iron bolts, the keel being rabbetted for the reception of planking. Stem and stern pieces are respectively of hackmatack and white oak, sided 5 inches, scarfed for planking, and riveted to keel and keelson. The stem is capped with composition casting.


6" Crown
Section at Frame 52 Looking For'd
Section at Frame 45 Looking For'd
Section at Frame 37 Looking For'd
Section at Frame 28 Looking Aft
Section at Frame 20 Looking For'd
Section at Frame 12 Looking For'd
Section at Frame 4 Looking For'd
Marine Engineering

CROSS SECTIONS OF LAUNCH AT VARIOUS POSITIONS ALONG LENGTH.

The frames are 1 by 1¼ inches, and of white oak. In way of engine space, however, they are 1½ by 1¼ inches. All are mortised into the keelson and slightly rounded on the inside. They are spaced 8 inches apart throughout. The floors are scored over keelson, and have a minimum depth above top of keelson of 4¼ inches. In the engine space they have a thickness of 1¾ inches. The bilge clamp is of yellow pine, measuring 4 by 1¼ inches amidships and tapered to the width of 2½ inches at the ends. The shelving, of the same material, is 3 by 1 inches and the mahogany covering board measures 5 by 1 inches.

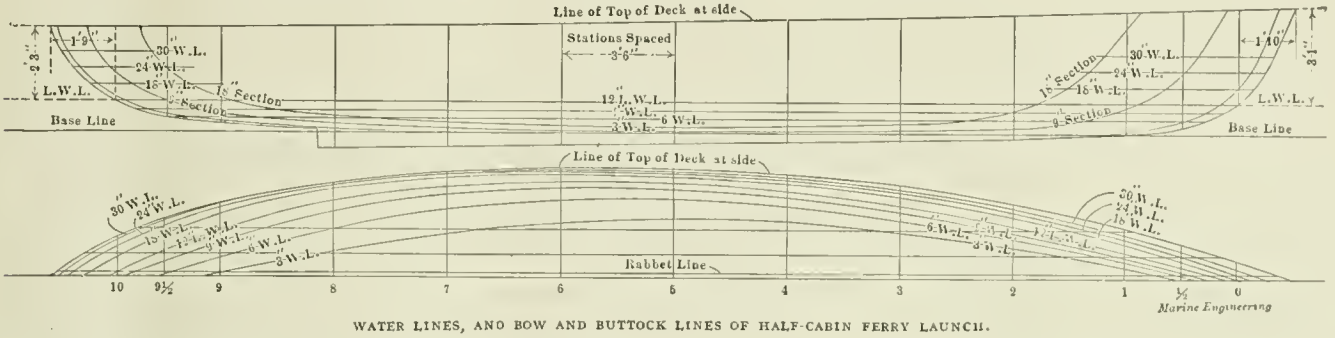
The planking is of white cedar about ¾ inch thick and riveted to frames. The sheer strake is of white oak; coaming in cockpits is of mahogany 8½ inches deep and ⅝ inch thick; the sides of the cabin are ⅞ inch thick, of Honduras mahogany, and measure 2 feet 6½ inches high. Beams of the house top are of oak, 1 inch by 1½ inches spaced 12 inches on centers, with 6-inch crown, and fitted at the ends into a 3½ by ⅝ inch mahogany strip. The top of the house is of white pine ⅝ by 4 inches, covered with 15-ounce duck laid in thick lead and glue, and bound by a 1½-inch mahogany half-round strip.

A watertight bulkhead is fitted at frame 8, at the after end of the forward cover deck, the after side of which has a mahogany finish. The bulkhead at the forward end of the cabin is also of mahogany, ⅝ inch thick; that at the after end of engine space and that at the after end of the cabin are of the same thickness and material. The deck house is fitted with eight fired glass fixed lights on the sides, measuring 17 by 24 inches, and one at the forward end, measuring 30 by 18 inches. There are also six air ports fitted in the sides, with inside measurement of 6 inches.

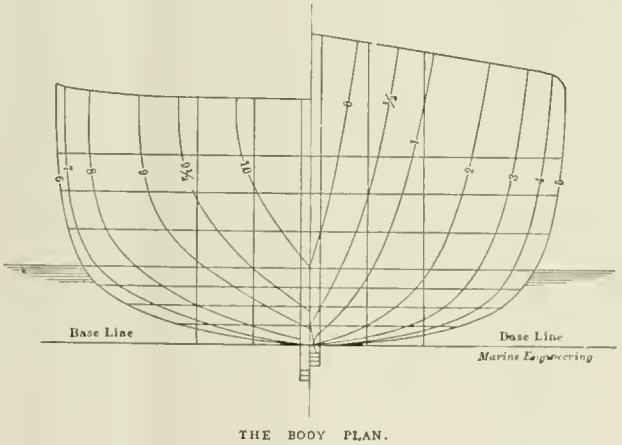
The rudder stock is 1½ inches in diameter and is made of bronze and fitted with quadrant. The rudder port is of brass pipe supported at the top. The rudder consists of ½-inch bronze plate and will be supported at the foot by a bronze casting connected with the propeller shaft strut. The steering gear is operated by a powerful wheel of automobile pattern, situated in the forward cockpit, while a vertical lever in the engine space gives a second point of control. Bronze wire tiller ropes leading through sheaves and fairleads are fitted. The gasoline tank is of copper and practically fills the space under the forward deck. The canopy top over the forward cockpit is carried on polished brass stanchions in brass sockets, and has a framing of galvanizd iron pipe with cover of heavy duck. A screen of glass, fitted in mahogany frame at the forward end of the cockpit and measuring 24 by 24 inches, swings back and stows under the canopy top when not needed.

It is desired to have power which shall at all times provide for a speed of twelve miles per hour, and the designers expect to get between thirteen and fourteen miles on trial. The engine, the pattern of which is not yet fixed, will be of about 25 horsepower, with four cylinders and of the four cycle type.

Contract for construction of the hull has been placed with The Fraser Hollow Spar and Boat Company, Greenport, N. Y.



WATER LINES, AND BOW AND BUTTOCK LINES OF HALF-CABIN FERRY LAUNCH.



THE BODY PLAN.

Progress of Naval Vessels.

The Bureau of Construction and Repair, Navy Department, report under date of February 10, 1906, the following percentage of completion of vessels building for the United States Navy:

				Jan. 1.	Feb. 1.
BATTLESHIPS.					
Virginia	19 knots.	Newport News Co.		98.	98 6
Nebraska	19 "	Moran Brothers Co.		84.24	86.17
Georgia	19 "	Bath Iron Works.		91.24	93.35
New Jersey	19 "	Fore River Shipbuilding Co.		95.5	96.5
Rhode Island	19 "	Fore River Shipbuilding Co.		99.	99.5
Connecticut	18 "	Navy Yard, New York, N. Y.		93 69	95.16
Louisiana	18 "	Newport News Co.		94.17	95.24
Vermont	18 "	Fore River Shipbuilding Co.		70.7	73.5
Kansas	18 "	New York Shipbuilding Co.		69 8	72.5
Minnesota	18 "	Newport News Co.		80.33	82.08
Mississippi	17 "	Wm. Cramp & Sons.		47 32	49.08
Idaho	17 "	Wm. Cramp & Sons.		45.39	47.19
New Hampshire	18 "	New York Shipbuilding Co.		33 4	37.1
ARMORED CRUISERS.					
California	22 knots.	Union Iron Works.		87.5	88.7
South Dakota	22 "	Union Iron Works.		86.2	87.3
Tennessee	22 "	Wm. Cramp & Sons.		91.66	94.53
Washington	22 "	New York Shipbuilding Co.		91.9	94.4
North Carolina	22 "	Newport News Co.		30.74	14.48
Montana	22 "	Newport News Co.		25.84	30.11
SEMI-ARMORED CRUISERS.					
St. Louis	22 knots.	Neafie & Levy Co.		86.	88.34
Milwaukee	22 "	Union Iron Works.		87.9	89.8
SCOUT CRUISERS.					
Chester	24 knots.	Bath Iron Works.		15.53	18.87
Birmingham	24 "	Fore River Shipbuilding Co.		18.2	21.
Salem	24 "	Fore River Shipbuilding Co.		17.6	21.1
SUBMARINE TORPEDO BOATS.					
Submarine No. 9		Fore River Shipbuilding Co.		46.9	51
" " 10		Fore River Shipbuilding Co.		37.8	43.3
" " 11		Fore River Shipbuilding Co.		39.9	43.5
" " 12		Fore River Shipbuilding Co.		38.7	43.1

Forced draft was first used for marine purposes on the Hudson River steamers prior to the Civil War. In 1882 it was introduced into the English Navy, and still later was applied in the merchant service.

Marine Engineering

Published Monthly by
MARINE ENGINEERING
INCORPORATED.
17 Battery Place, - - NEW YORK
8 Finsbury Square, - - LONDON, E. C.

H. L. ALDRICH, President and Treasurer

PROF. W. F. DURAND, Advisory Editor

SIDNEY GRAVES KOON, Editor

GEORGE SLATE,
Vice-President and Advertising Representative

Branch Offices. Philadelphia, Pa., Machinery Dept., The Bourse, S. W. Anness.
Boston, Mass., 170 Summer St., S. I. Carpenter.
Chicago, 34 Clark Street, Howard S. Moss.

TERMS OF SUBSCRIPTION.

	Per Year.	Per Copy.
United States, Canada and Mexico	$2.00	20 cents
Other countries in Postal Union	10/6	1/-

Entered at New York Post Office as second-class matter.

Copyright, 1906, by Marine Engineering, Inc., New York.
Marine Engineering is registered in the United States Patent Office.

Notice to Advertisers.

Changes to be made in copy, or in orders for advertisements, must be in our hands, in New York, not later than the 10th of the month, to insure the carrying out of such instructions in the issue of the month following.

The edition of the March issue of Marine Engineering *comprises 6,500 copies. We have no free list, accept no return copies and issue only enough to supply the regular demand, so that the 6,500 copies represent legitimate circulation.*

NOTICE.

Marine Engineering is printed by a firm which is fighting the printers' strike. That strike is not yet over; but matters are getting into better shape every week, and no delays are anticipated.

The American Ship.

"Why should senators waste time over the question whether the Gallinger bill for the restoration of the American ship to its old place on the ocean is a subsidy or a bounty, or a measure analogous to the land reclamation act, or what not?

Open the way for the American flag to its proper place at the front of the world's carrying trade, and call it a subsidy, or by any other name.

Redeem our one great national failure, and call the redemption fee a bounty if you will.

Rehabilitate the American merchant marine, and compare the process to the land reclamation legislation, or to anything else in sight.

The people are not afraid of the word 'subsidy,' or of any other word that may be used to describe the method of assuring that restoration and revival which President Roosevelt had in view when he said to Congress:

'To the spread of our trade in peace and the defence of our flag in war a great and prosperous merchant marine is indispensable. We should have ships of our own and seamen of our own to convey our goods to neutral markets, and in case of need to re-enforce our battle line.'

Let us have them. Let the lack of them no longer disgrace this nation."—New York *Sun*.

We heartily second the motion.

The Metric System.

At present writing there seems to be a more or less concerted movement looking toward making compulsory the use of the metric system in all branches of the government service, and making it the only legal standard in commercial work. One of the leading metropolitan papers has been pushing the campaign with much vigor, but with very little appreciation of the real difficulties surrounding the situation. It seems to have been assumed that the mere enactment of a law such as is called for would be quite sufficient to start the thing in motion, and push it along immediately to a successful conclusion. It is a fact, however, that in the engineering profession, which is the one profession above all others making the greatest use of measurements of all sorts, the introduction of a new system would call for a vast amount of expenditure, and create untold confusion. It has been estimated by one of the officers of the Westinghouse Electric & Manufacturing Company that the replacement of the tools, dies, jigs, etc., in their shops by similar implements conforming to the requirements of the metric system would cost no less than three hundred thousand dollars; while if the change were to include their drawings, this figure would be nearly doubled. With such an expense as this in a single establishment, it is quite apparent that the cost to the manufacturing interests of the country could be placed with entire conservatism at not less than one hundred million dollars.

There is, of course, an extremely logical relation as among the various units—linear, volumetric and gravimetric—in the metric system, and on this account it is widely heralded as affording most excellent facilities for computation. This would be true if it were necessary to reduce from volume to weight or vice versa of simply a given quantity of pure water, which is the material used as the connecting link between the two. Unfortunately, however, it is occasionally necessary to measure iron or steel or some other material not at all like water, and this necessitates at once the introduction of a constant reduction factor covering the weight per cubic meter of said substances. It is readily seen that such a computation is not a particle more simple than would be a computation based on feet and pounds, by making use of the weight per cubic foot of the substance in question. Hence, the alleged greater simplicity of the metric system, while theoretically most beautiful in conception, is practically more or less of a fiction.

For the naval architect and marine engineer little advantage would be obtained by the change, because not only would the requirement have to be met of measuring iron and steel, but the very water entering into the computations of a marine man is in most cases sea water, which has a density greater by about three percent than that of pure water, and hence would require an introduction of a constant multiplier, which is no improvement over the present method of computation.

Engineers in the Navy.

"We have now no engineering corps, though we used to have the best in the world."—Melville.

"The United States government requires that a merchant ship of 3,400 horsepower shall carry no less than three licensed engineers; while it may be assumed, from what we know of the matter, that *not a man connected with the engineering force on the Bennington would have been able to obtain a license.*"

Both of these quotations are taken from the September number of Marine Engineering. The latter of the two has been made the basis of an attack in the current number of the *Proceedings of the United States Naval Institute,* in which it is characterized as a "wild statement which can only have emanated from ignorance or malice." If it is a question of ignorance as to how the navy can be expected to get on without proper complement of engineer officers, we immediately plead guilty to the charge. If, on the other hand, malice consists in an attempt to correct the set of circumstances which made possible the terrible disaster to the *Bennington*, and the system to which that set of circumstances could trace its origin, we again plead guilty.

The article above mentioned contains within itself a proof of the assertion which we made in italics in the editorial quoted. It has never been claimed that any one on that ill-fated ship, aside from the ensign, who was in responsible charge of her machinery at the time of the accident, was in any way qualified to take charge of that machinery. It, therefore, remains only to show that this officer would have been unable under the laws governing the United States Steamboat Inspection Service to have obtained a license permitting him to exercise the authority and assume the responsibility which were his at that time. The article includes a number of appendices, in one of which is a "Statement of Additional Requirements Necessary to Secure United States Merchant Engineer Licenses," which reads in part as follows:

"No person shall receive an original license as an engineer or assistant engineer****who has not served at least three years in the engineers' department of a steam vessel; ****provided that **** any person graduated as a mechanical engineer from a duly recognized school of technology may be licensed to serve as an engineer of steam vessels after having had not less than one year's experience in the engineer department of steam vessels. **** Any person having had a first assistant engineer's license for two years, and having had two years' experience as second assistant engineer, shall be eligible for examination for chief engineer's license." It is again stated that in the examinations the examination itself has a weight of only ten percent, the general qualifications of the candidate, such as experience, etc., having a weight of ninety percent. Taking these quotations from the appendix to the article, and viewing them in connection with the fact that the ensign had not been out of the Academy a sufficient length of time to have obtained the experience required by law for a merchant marine engineer's license, it is quite evident that the statement in our September number was neither "wild" nor unjustified, but was absolutely in accordance with the facts of the case as they have come to hand. Be it understood that this is nothing against the ensign himself; but it is distinctly against the perpetration of a system which could place an unqualified and inexperienced officer in a position of such responsibility.

We have argued all along, not for a return to the old engineer corps, but for the adoption of some system embodying in a large measure the common sense which is so conspicuously absent from the way things are now handled, and we have not hesitated to refer to the method of handling ships in the merchant marine, and the excellent success obtained by that method. We fully realize that conditions in the merchant marine are widely different from those in the navy, and that the system in detail, successfully in vogue in the one, would not necessarily be a success in the other. It does, however, afford a splendid basis for observation of methods which are successful, and many of which could be readily adopted in the navy without prejudice of any sort.

A part of the argument in the article under discussion is very pertinent. We wish to quote as follows:

"It was most certainly never contemplated that a young ensign or midshipman should be placed in a position of full responsibility in any one branch, as was the case with the chief engineer of the *Bennington.***** Up to the time of the disaster the spirit to inspire a movement towards steam engineering was almost entirely lacking, and **** the time and attention given to steam engineering was sadly below that given to the other branches.**** The chief engineer of the *Bennington* was a young ensign, recently graduated with a sound groundwork of engineering knowledge, but of insufficient years to enable him to fully appreciate the responsibilities and duties of his position. In the days of the engineering corps no such position was ever held by an assistant engineer of the same lack of experience."

In this connection we can but repeat the suggestion made editorially in our issue for January: "Make all officers engineers first, and line officers afterwards." The modern warship is simply a floating box of machinery of varying degrees of delicacy, but of immense quantity and very considerable complexity. The proper handling of this maze of machinery requires engineering skill of the highest order, and it is fast coming to be recognized that engineering is the only profession really required on board such a vessel. Both theoretical knowledge and experience are necessary. The Naval Academy can provide the one, but not the other.

The need is very urgent. Until we have an adequate engineering force—adequate in point of skill and experience as well as numbers—we cannot consider that our navy has any sort of general efficiency of which we have a right to be proud.

"Every officer on a modern war vessel must be an engineer, whether he wants to or not." Roosevelt.

ABSTRACT FROM LLOYD'S REGISTER FOR YACHTS.

EDITION OF 1905-1906.

ARRANGED BY HARRISON S. TAFT.

1. Measurements for Scantling Numbers.

1. Length. *L*. Distance in feet between the points on the outside of the stem and stern post or counter which are .15 of the rule depth below top of beams at said points on center line.

2. Breadth. *B*. Maximum molded beam.

3. Depth. *D*. Distance in feet at middle of length (*L*) from top of a bar or a flat plate keel to top of upper deck beams at center line, assuming a round up of 1-4″ per foot of beam.

4. Girth. *G*. Distance in feet at middle of length (*L*) measured along the molded edge of the frame bar, from center line to top of beams at side of ship.

5. Bilge Diagonal. *N*.

Distance in feet at middle of length (*L*) from top of upper deck beam at center line to molded edge of frame, as measured on a diagonal drawn from said point on upper deck to the intersection of the horizontal base line and the vertical half-breadth line.

6. Transverse Number.

$TN = \frac{1}{2}B + D + G + 2N.$

7. Longitudinal Number.

L/D not over 7: $LN = L \times TN.$

L/D over 7: $LN = (L \times TN)\left(\frac{L}{10D} + .3\right)$

8. Equipment Number.

$E = (L \times TN)$ + twice the product of the length and height in feet of any erections that may be fitted above the upper deck.

9. Scantlings under transverse number; frames; reverse frames; floor plates; bulkhead plating.

10. Scantling under longitudinal number; bar keels; stems; stern posts; shell plating throughout; deck stringers; tie plates; all fore and aft keelson and stringer angles; center keelsons; wood deckings; rudders; members of double bottoms; riveting of butts, etc.

11. Size of beams is regulated by the length of beams amidships.

2. Scarphs.

Scarphs of bar keels, stems and stern posts are to be in length not less than nine times the thickness given by tables for a bar keel.

3. Stems.

Stems may be gradually reduced from full size at the heel to ¾ of their full sectional area at the head.

4. Stern Frames.

1. The stern frames may be gradually reduced from full size at the counter to the head, where their dimensions can be the same as required at the head of the stem.

2. The part of the stern frame forming the lower part of the propeller aperture is to have its greater dimension horizontal.

3. The heel, forming part of the keel, is to extend with a fair taper forward of the post for a distance equal to at least five times the rule depth of the keel where there is no propeller aperture, but not less than eight times said depth where there is an aperture.

4. Stern frames cast in one piece are to be let fall on hard ground after being raised through an angle of 45°.

5. Stern frames cast in more than one piece, rudders, steering quadrants and tillers are to be dropped on hard ground from a height of from 7 to 10 feet; then to be strung up and well hammered with a sledge of not less than 7 pounds.

TABLE 1.—TYPE OF CENTER LINE KEELSON ON TOP OF FLOORS.

Type of Keelson.	Vessels Fitted with Bar Keels.		[a] Vessels with Flat Plate Keels Fitted with an Intercostal Plate Keelson.
	Bar Keels Only.	[a] With an Intercostal Plate Keelson Between Floors.	
	Longitudinal Numbers.		
D A	Under 5,800	Under 13,800	Under 7,900
D A + B P	5,800 " 13,800	13,800 " 35,000	7,900 " 25,800
K P + T A	13,800 " 25,800	35,000 and over.	25,800 " 35,000
K P + T A + R P	25,800 and over.	... .	35,000 and over.

D A = double angles. B P "= bulb" plate. K P = vertical keelson plate. T A = top angles. R P = rider plate. + means "with a."

[a] Intercostal plates to have double clips to floors and to a flat plate keel.

5. Center-Line Keelsons.

1. A center-line keelson must be fitted when the half breadth on top of floors is 2 feet or over.

2. Said center keelsons are to extend as far forward and aft as possible, and are to maintain their midship scantling for 1-2 length amidships.

3. In vessels with fine ends deep floor plates are preferable to extending the center keelson to the extreme ends of the ship. Butts of said keelsons are to be kept clear of all keel and garboard butts; those of the rider plates being kept clear of those of the center keelson and its angles.

6. Frames.

1. All frames are to extend from the keel to the gunwale.

2. When the transverse number is 68 or over, before and abaft the 3-5 vessel's length amidships, the thickness of the frames may be reduced 1-20 inch if the depth forward and aft of said 3-5 length, from top of floors to top of beams is less than amidships.

3. The frames of the aft counter are to be of the same scantling as the main frames.

4. Heel pieces, when fitted to butts of frames, are to have three rivets in each flange on each side of the butts. They are to extend for 3-5 length amidships.

5. When ballast is carried between the floors the frames are to be worked double to above the height of the ballast, the doubling pieces being of the same size as the frame bars themselves.

6. In way of double bottoms the horizontal and vertical flanges of the frames can be of the same width.

7. Double frame angles are to be worked at all watertight bulkheads.

7. Floor Plates.

1. A floor plate is to be fitted to every frame. They are to maintain their midship scantling for 1-2 length amidships.

2. According to the depth they are to be worked straight on top or curved up the bilge in a fair curve to twice their center-line depth.

3. In the engine space the floors are to be 1-20 inch thicker than midship floors, those in the boiler space being 2-20 inch thicker.

4. Bulkhead floor plates are to be deep enough to admit of riveting the bulkhead plating to said floors above the reverse frames. They are to be in all cases of the same weight as the midship floors.

5. In deep, narrow-keel vessels the floor plates are to be of sufficient depth to securely fasten said parts of the vessel together.

6. Water courses are to be provided so as to efficiently drain the ship.

7. In vessels of great power the after floor plates are to extend well above the screw shaft, holes being cut in said floors for said shaft.

8. Floor plates not made in one piece should have their butts located alternate on opposite sides of the middle line.

9. Transom Floor. A deep floor plate is to be fitted in way of the stern post and fastened to same by double angles. Said floor plate shall be at least of the same weight as midship floors.

8. Reverse Frames.

1. A reverse frame is to be fitted to the top edge of all floor plates.

2. They are to extend up the frames to the top edge of the side stringer or cabin-sole stringer angle bar alternately, when the transverse number is 36 and under 48; to top of said cabin stringer angle bar and to four feet above same alternately when said number is 48 and under 72; to top of said cabin stringer angle bar and to the upper deck alternately when said number is 72 and above. In the way of any deck erections and of all large deck houses, all the reverse frames are to extend to the upper deck, or partial bulkheads be fitted.

3. The reverse frames can be reduced 1-20 inch in thickness before and abaft the 3-5 length amidships when the transverse number is 100 or over and the depth from top of floors to top of beams is less than said depth amidships.

4. The reverse frames are to be worked double wherever ballast is carried on top of floors. They are also to be worked double throughout the engine and boiler spaces extending from bilge to bilge. In the engine space they are to be 1-20 inch, in the boiler space 2-20 inch thicker than amidships.

5. Angle butt straps at all butts are to be of sufficient length so as to take three rivets on each side of the butts.

6. In way of double bottoms the horizontal and vertical flanges of the reverse frames can be of the same width.

9. Floor, Bilge and Side Keelsons.

1. A Floor Keelson consisting of double angles riveted back-to-back with intercostal plates, secured to the shell, is to be fitted on top of floors on each side of the center when the half breadth at level of top of floors is 8 feet or above.

2. A Bilge Keelson is to be fitted when the midship girth from center line at top of floors to top of beams at sides exceeds 12 feet, and no floor keelson or side stringer is called for.

3. A Side Stringer is to be fitted wherever the frame girth amidships, or at any other part of the vessel, from top of floors to top of beams at side, or where said girth from the cabin stringer to the upper deck beams at sides exceeds 8 feet.

TABLE 2.—TYPE OF SIDE STRINGERS.

Longitudinal number....	Under 4,900.....	4,900 under 40,000.....	40,000 and above.
Type of stringers.....	Single angles..	Double angles.....	Double angles chocked to shell.

4. When the frames are stayed to the cabin beams the side stringers may be dispensed with.

5. The floor and bilge keelson and the side stringers are to extend to the extreme ends of the ship and are to maintain their midship scantling for 1-2 length amidships. The bilge keelson and side stringers are to be attached to breast hooks.

10. Keelson Clips.

1. Short angle clips are to be fitted on all frames and top of floors in way of the center, floor and bilge keelsons and side stringers, except where intercostal plates are fitted.

11. Deck Beams. Beam Knees.

1. Beams are to be fitted to alternate frames with a stanchion at the center line or near thereto. When alternate reverse frames extend to the upper deck the beams should be located on the frames having reverse frames. Beams are to maintain their midship scantling for 3-4 length amidships, with a reduction before and abaft said 3-4 length.

2. When the girth from top of floors to top of upper deck beams at sides is 12 feet or above, a tier of cabin sole beams is to be fitted. When said girth from top of floors to top of cabin beams is 12 feet or more a tier of orlop beams is to be fitted.

3. Half beams, where used, are to be fitted to alternate frames, having a double lug attachment to the fore and aft carlings or coamings.

4. Under windlasses or deck houses and at the ends of all large deck openings the beams are to be of increased size or else extra stanchions provided. Strong beams are to be fitted in the machinery space. Angle beams are to be fitted to every frame in the way of watertight flats. In the way of masts in sailing or auxiliary yachts the beams are to be worked at every frame or otherwise strengthened.

5. When it is necessary to dispense with a cabin or orlop beam, web frames, deep framing or otherwise is to be fitted.

TABLE 3.—SIZE AND NUMBER OF RIVETS FOR BEAM KNEES.

Length of Beam Amidships.	8 under 9	9 under 10	10 under 11	11 under 12	12 under 13	13 under 14	14 under 15	15 under 16	16 under 17	17 under 18	18 under 19	19 under 20	20 under 21	21 under 22	22 under 23	23 under 24	24 under 26	26 under 28	28 under 30	30 under 32	32 under 34	34 under 36
Depth of beam knee. Inches.....	8	8½	9	9½	10	10½	11	11½	12	12½	13	13½	14	14½	15	15½	16	17	18	19	20	21
Number of rivets in knee.....	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	5	5	5	5	5
Diameter of rivets.....	⅝	⅝	⅝	⅝	⅝	⅝	⅝	⅝	⅝	⅝	¾	¾	¾	¾	¾	¾	¾	¾	¾	¾	¾	⅞

Beam knees are to measure across their throat not less than $\frac{6}{10}$ of their depth.

12. Deck Stringers and Tie Plates.

1. The upper deck stringer plates are to maintain their midship scantling for 1-2 length amidships.

2. When the frames extend through an upper deck stringer plate the gunwale bars are to be worked intercostally between said frames, with an auxiliary gunwale bar of equal scantling worked continuously on the inside of the frames, being riveted to the stringer plate.

3. Stringer plates are to be fitted to the cabin deck beams, having the intercostal shell clips and the continuous face angle as for an upper deck stringer, as stated in paragraph 2.

4. The cabin deck stringer may have lightening holes cut in same between the beams, provided said holes do not exceed 1-3 the stringer's breadth in width, and the length or the combined length does not exceed 1-3 the beams' spacing.

5. The butts of all deck stringers and angles are to have at least a two-frame space shift from each other and from the butts of their adjacent shell strakes.

6. Tie plates, equal to the weight of the stringer plates, are to be worked on each side of all deck openings —extending all fore and aft—with diagonal tie plates in addition in way of the masts on sailing or auxiliary yachts.

7. In way of large deck openings the tie plates are to be of increased width, or the deck plated over in way of said openings. An angle bar is to be worked connecting the tie plates to the fore-and-aft carlings or coaming plates.

8. Mast Partners are to be of the same thickness as the stringer plates and be in breadth at least three times the diameter of the mast hole. An angle bar or bulb angle is to be fitted so as to allow for wedging.

13. Stanchions.

Stanchions should have solid welded heads and heels, with at least a two-rivet connection at each end.

They should be fitted vertically over each other under every beam. When for any reason they are omitted, a girder should be worked so as to efficiently support the deck beams. Additional stanchions should be fitted under the windlass, deck houses, and at ends of large deck openings.

14. Bulkheads.

1. A watertight bulkhead is to be fitted forward extending to the upper deck, in all steel yachts 100 feet or more in length.

2. A watertight bulkhead is to be located at both ends of the machinery space, extending to the upper deck, in all steel yachts of 50 but under 100 feet in length. The space around the stern tube should be enclosed in a watertight compartment in yachts of this size. When of 100 but under 280 Ieet in length, four watertight bulkheads are to be fitted (three when the length is 100 but under 220 and the machinery is located aft) extending to the upper deck.

3. The bulkhead plating is to have a double angle bar attachment to the shell, deck and inner bottom plating.

4. The vertical stiffeners are to be of reverse frame size, spaced not further apart than the frame spacing. When the depth from the top of the cabin beams to top of keel or inner bottom is 8 feet or above, said vertical stiffeners are to equal the scantling of the frames. The lower ends of all vertical stiffeners are to extend down to the frames (being well riveted to the floor plates), or be secured to the inner bottom plating by bracket plates. When the depth of a bulkhead exceeds its breadth the stiffeners are to be worked horizontally. A plate of the same scantling as the tie plates is to be fastened to the bulkhead in way of the cabin sole stringer for supporting the ends of the deck planking.

5. When doors are fitted in a watertight bulkhead they are to be so arranged that they can be worked from the upper deck.

6. The watertightness of the end collision bulkheads is to be tested by filling the end peaks with water to the height of the load waterline.

15. Shell Plating.

1. The shell plating is to maintain its midship weight for 1-2 length amidships.

2. In single-screw vessels those plates which are attached to the propeller post are to be of midship weight; the boss plates being 2 pounds heavier than the midship plates of the same strake.

3. The weight of the sheerstrake may be less than otherwise if the weight of the strake or strakes below said sheerstrake and that of the upper deck stringer are correspondingly increased.

4. Frame liners in way of the outside strakes are to be of the same width as the frame angle flange and be worked in one length. Bulkhead liners are to be one frame space in breadth.

5. Butts of adjoining strakes of the shell plating are to have a shift of at least two frame spaces; those of alternate strakes at least a one-frame space shift.

6. Butts of the garboards are to be kept clear of the keel scarphs and are to be at least two frame spaces clear of each other on opposite sides of the vessel.

TABLE 4.—BREADTH OF SHELL PLATE STRAKES.

Rule depth. Feet.....	8 under 10	10 under 12	12 under 14	14 under 16	16 under 18	18 under 20	20 under 22
Maximum breadth. Inches,..	38	40	42	44	46	48	50

In order to comply with riveting table.

16. Riveting.

TABLE 5.—DIAMETERS OF RIVET HOLES.

Diameter of rivet. Inches.....	$\frac{5}{16}$	$\frac{3}{8}$	$\frac{7}{16}$	$\frac{1}{2}$	$\frac{9}{16}$	$\frac{5}{8}$	$\frac{11}{16}$	$\frac{3}{4}$	1	$1\frac{1}{8}$
Diameter of rivet hole. Inches.....	$\frac{7}{16}$	$\frac{7}{16}$	$\frac{9}{16}$	$\frac{9}{16}$	$\frac{11}{16}$	$\frac{13}{16}$	$\frac{13}{16}$	$\frac{15}{16}$	$1\frac{1}{16}$	$1\frac{3}{16}$

1. The thicker of two plates is to regulate the diameter of the rivet used in securing them together.

2. All double and treble riveting, and all butts of the shell plating are to be chain fashion, except for the keel, stem and stern post, which are to be zigzag riveted.

3. Butt laps are to have complete rows of rivets.

4. With single butt straps alternate rivets may be omitted in the third row of a treble-riveted butt strap joint.

5. Edge strips for flush shell plating are to be worked continuously; their thickness being not less than that of the plates they connect.

6. Countersinks are to extend entirely through the thickness of the plate or angle bar.

7. All rivet holes are to be punched from the faying surfaces opposite each other in the adjoining parts, laps, lining pieces, butt straps and frames.

8. Rivet holes are not to be punched in frames at the turn of the bilge or where the curvature is great until after the frames have been bent to the required shape.

9. All work to be carefully closed up with nuts and screw bolts before the riveting is begun.

10. The following to be single riveted:

(*a*) Butts and edges of bulkhead plating.

(*b*) Butts and seams of inner bottom plating (outside of machinery space) except middle line and margin strakes.

(*c*) Seams of deck plating.

11. The following to be double riveted:

(*a*) Butts of deck tie plates and deck plating.

(*b*) Middle line and margin strakes of inner bottom plating. Also all butts of said plating in the machinery space.

12. The following to be treble riveted:

(*a*) Butts of the center line girder plates of double-bottom vessels.

(*b*) Butts of the center line keelson.

(*c*) Butts of all rider plates.

(*d*) Butts of floor plates not made in one piece.

(*e*) Angle staps fitted to keel, keelson and stringer angle bar butts.

TABLE 6.—RIVETING SCHEDULE.

Longitudinal Number.	Butts of						Rivets in Bar Keels, Stems, Stern Posts and Rudders.	
	Keel Plate.	Garboard Strakes and Strake Next Below the Sheer Strakes.	Shell Plating between the Garboard Strakes and the Strake Next Below the Sheer Strakes.	Sheer Strakes and Upper Deck Stringer Plate.	Cabin Sole Stringer Plate.	Edges of the Shell Plating Fore and Aft.	Diameter. Inches	Spacing. Inches.
1,200 under 2,200	D R T	S R T	S R T	D R—½ L	S R T	S R T	⅝	3½
2,200 " 3,000	D R T	S R T	S R T	D R—½ L	S R T	S R T	¾	3¾
3,000 " 4,100	D R T	D R—½ L	S R T	D R—½ L	S R T	S R T	¾	3¾
4,100 " 4,900	D R T	D R—½ L	S R T	D R—½ L	S R T	S R T	⅞	4⅜
4,900 " 6,800	D R T	D R—½ L	D R—½ L	D R T	S R T	S R T	⅞	4⅜
6,800 " 10,500	T R—½ L	D R T	D R—½ L	D R T	S R T	S R T	⅞	4⅜
10,500 " 17,500	T R—½ L	D R T	D R T	D R T	S R T	S R T	1	5
17,500 " 25,800	T R—½ L	D R T	D R T	T R—½ L	D R T	S R T	1	5
25,800 " 32,600	T R—½ L	D R T	D R T	T R—½ L	D R T	D R T	1	5
32,600 " 40,000	T R T	T R—½ L	D R T	T R—½ L	D R T	D R T	1	5
40,000 " 45,300	T R T	T R—½ L	D R T	T R—½ L	D R T	D R T	1⅛	5⅝
45,300 " 48,100	T R T	T R—½ L	T R—½ L	T R—½ L	D R T	D R T	1⅛	5⅝

S R T = single riveted throughout. D R T = double riveted throughout. T R T = treble riveted throughout.
D R — ½ L = double riveted for ½ length amidships. T R — ½ L = treble riveted for ½ length amidships.
When double riveting is called for ½ length amidships single riveting is to be used at ends.
When treble riveting is called for ½ length amidships double riveting is to be used at ends.

17. Double Bottoms.

1. When a side bar keel is fitted the center line vertical keelson plate is to extend down to the bottom of the keel with a side plate riveted on each side, so that the combined thickness of the three plates shall equal that required for a bar keel.

2. The center line keelson is to have a double angle bar connection to the inner bottom plating.

3. Solid manhole floor plates are to be fitted to every frame. They are to be built in one length from the center line keelson to the margin plate.

4. An intercostal side longitudinal clipped to floors, shell and inner bottom plating is to be fitted on each side, midway between the center line keelson and the margin plates, extending all fore and aft, where the half breadth of the inner bottom is 8 feet or over. Additional intercostal girders are to be fitted in the engine space.

5. When the inner bottom is discontinued the regular keelsons should lap over into the double bottom space for at least three frame spaces, and be connected to the longitudinal girders of said space; or else other means should be provided for maintaining continuity of strength.

6. Solid frame brackets are to be fitted outside of the margin plates to every frame, with the reverse frames fitted to their upper edge.

7. As far as possible angle clips are to be worked opposite to each other, on each side of a plate.

8. Throughout the engine and boiler spaces the floor plates, and frame brackets on the outside of the margin plates, are to have a double clip connection to their respective girder. Otherwise, a single clip connection may be used.

9. The reverse frames and all vertical angle clips in the boiler space are to be 1-20 inch thicker than otherwise.

10. Manholes are to be cut in the side girders, floor plates, and inner bottom plating so as to allow of free access to the double bottom space, the edges of said manholes being made smooth. No manhole is to be cut in the center line vertical keelson.

11. There shall be five 3-4 inch rivets in each flange of the vertical clips forming the connection between the floor plates and brackets to the margin plates.

12. There shall be a well, one frame space wide, in the aftermost part of the engine room when a double bottom is worked throughout the boiler and engine space.

13. Means should be provided for a free flow of air from one division to another, either by cutting the liners short or making holes in the floor plates as high up as possible.

14. Double bottoms are to be tested for watertightness by a head of water at least equal to the deep load draft of the ship.

18. Valves: Cement, Etc.

1. No sluice valve or cock is to be fitted to the collision bulkhead. When fitted to other watertight bulkheads they must be arranged to work from above the waterline.

2. All head and stern pumps are to be provided withsea cocks fitted next to the shell plating.

3. Soil pipes which are attached to the shell plating below the waterline are to have the lower lengths of steel or iron extending some distance above the waterline. If the remaining parts of said pipes be of lead they must be properly protected externally with either zinc or iron.

4. A sounding pipe is to be fitted on each side to all hold and ballast tanks, with a doubling plate under same.

5. The total area of the perforations in bilge suction pipe strainers should be double that of the cross section of said pipes.

6. The frames and plating of the bottom of all vessels should be efficiently covered with some approved cement.

19. Rudders.

1. The main piece or stock of a rudder frame is to have a straight taper from below the top pintle to the heel. In double plated rudders the stays or arms are to be fitted opposite to the pintles.

2. The main piece or stock of single plated rudders which have their arms keyed to said stock should have a groove on its after side, equal in depth to the thickness of the rudder plate.

3. The arms of single plated rudders are to be placed alternately on opposite sides of the rudder plate.

4. The diameter of the rudder head in steam yachts is to be not less than that given by the formula:

$$d = .12\sqrt[3]{A \times D \times (20 + S)^2}$$

where d = diameter of rudder stock in inches.

A = total area of rudder abaft center of stock, in square feet.

D = distance in feet of center of gravity of area A abaft the center of the rudder stock.

S = speed of vessel in knots.

20. General Notes.

1. In sailing and auxiliary yachts the framing in way of each mast should be efficiently strengthened according to the rig of the vessel.

2. Pine decks are to be laid with their grain vertical. Teak decks may be 1-6 less in thickness than required for other kinds of wood.

TABLE 7.—RENEWAL OF CHAIN CABLES WHEN WORN.

Original Size of Chain Cable. Inches.	To be Renewed When Worn to	Original Size of Chain Cable. Inches.	To be Renewed When Worn to	Original Size of Chain Cable. Inches.	To he Renewed When Worn to
1 1/16	29/32	1 5/8	1	1 9/16	1 3/32
1 1/8	1 1/32	1 11/16	1 1/16	1 5/8	1 5/32
1 3/16	1 1/16	1 3/4	1 1/8	1 11/16	1 1/4
1 1/4	1 3/32	1 13/16	1 3/16	1 3/4	1 9/32
1 5/16	1 1/8	1 7/8	1 7/32	1 13/16	1 5/16
1 3/8	1 5/32	1 15/16	1 9/32	1 7/8	1 11/32
1 7/16	1 3/16	2	1 11/32	1 15/16	1 23/32

21. Rivet Spacing. Lloyd's Yacht Register.

	Dias.
1. In edge riveting, center to center of rows	1½
2. In butts of plating, center to center of rows	2
3. In butts of outside plating, stringers, center keelsons, and floor plates	3½
4. In butts and edges of inner bottom plating	4
5. In edges of outside plating (forward and aft) and bulkhead plating; butts of bulkhead plating; upper deck stringer angles	4½
6. In bulkhead frames when caulked; keel angles; bar keels	5
7. In frames; reverse frames; floors; keelson; beams; and bulkhead stiffeners	7
8. Shell clips to stringers and intercostal plates. 4 rivets in each flange.	
9. No rivet is to be nearer the edge of a plate or of an angle bar than its own diameter.	

The United States Civil Service Commission announces examination on March 14 for the position of marine fireman at $540 per annum and rations. Applicants should apply to the Commission in Washington for form 1093.

The United States Civil Service Commission announces examination March 21 and 22 for vacancies in the position of topographic draftsman in the Postoffice Department at $900 per annum. Applicants should apply for form 1312.

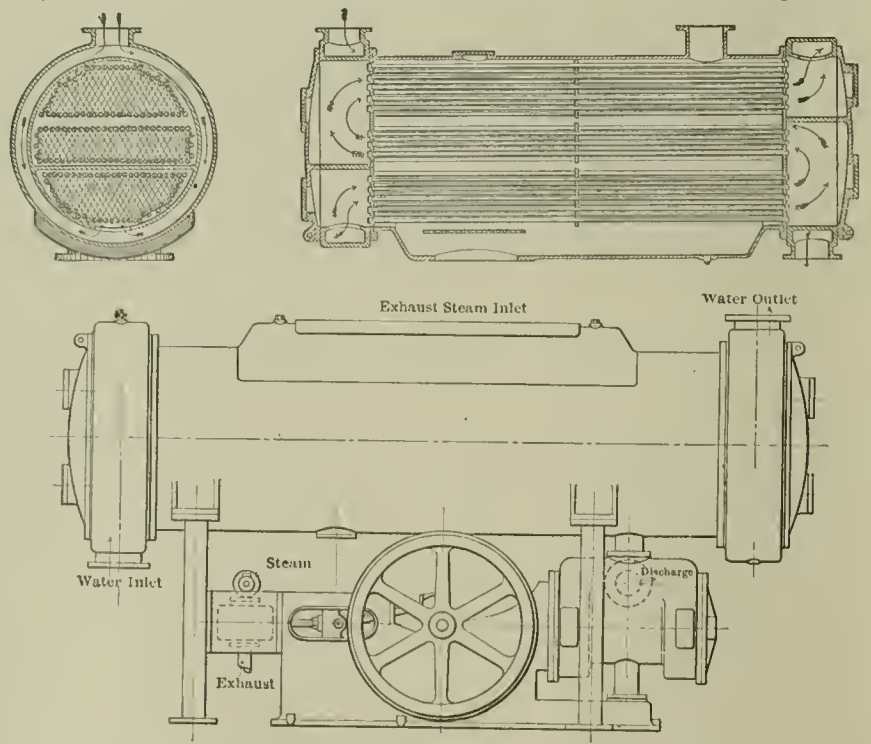
TABLE 8.—LLOYD'S YACHT REGISTER. WIDTH OF BUTT LAPS AND BUTT STRAPS. SPACING OF RIVETS.

Weight of Plate. Lbs.		Diametral Pitch.	4	6	8	10	12	14 to 18	20 to 26	28 and 30
Diameter of Rivet. Inches.			$\frac{5}{16}$	$\frac{3}{8}$	$\frac{7}{16}$	$\frac{1}{2}$	$\frac{5}{8}$	$\frac{3}{4}$	$\frac{7}{8}$	1
Width of:	Single riveted butt lap	..	$1\frac{1}{8}$	$1\frac{3}{4}$	2	$2\frac{1}{4}$	$2\frac{5}{8}$	..	..	..
	Double " " "	..	$2\frac{1}{2}$	$2\frac{1}{8}$	3	$3\frac{3}{8}$	$4\frac{1}{2}$	5	6	..
	Treble " " "	..	..	..	..	$5\frac{1}{8}$	$6\frac{1}{4}$	$7\frac{1}{8}$	9	$10\frac{1}{2}$
	Single " " strap	..	$2\frac{1}{8}$	3	$3\frac{1}{8}$	4	$4\frac{1}{8}$	..	..	..
	Double " " "	..	$4\frac{1}{2}$	5	$5\frac{1}{2}$	$6\frac{1}{8}$	8	$9\frac{3}{4}$	$11\frac{1}{4}$	..
	Treble " " "	..	..	..	..	..	..	$14\frac{1}{2}$	$16\frac{3}{4}$	19
	Single " seam lap	..	$1\frac{1}{2}$	$1\frac{1}{8}$	$1\frac{3}{4}$	2	$2\frac{1}{4}$	$2\frac{1}{4}$	3	..
	Double " " "	..	..	..	..	3	$3\frac{3}{4}$	$4\frac{1}{8}$	$5\frac{1}{4}$	6
	Single " edge strip	..	..	..	..	..	..	..	..	..
	Double " " "	..	..	..	..	..	..	..	..	..
Spacing of rivets.	1.—Edge riveting. Center to center of rows	$1\frac{1}{8}$	$\frac{7}{16}$	$\frac{9}{16}$	$\frac{5}{8}$	$\frac{3}{4}$	$\frac{15}{16}$	$1\frac{1}{8}$	$1\frac{5}{16}$	$1\frac{1}{8}$
	2.—Butts of plating. " " " " "	2	$\frac{5}{8}$	$\frac{3}{4}$	$\frac{7}{8}$	1	$1\frac{1}{4}$	$1\frac{1}{8}$	$1\frac{3}{8}$	2
	3.—Butts of shell plating, stringers, center keelsons and floor plates	4 and $3\frac{1}{8}$	$1\frac{1}{4}$	$1\frac{1}{8}$	$1\frac{3}{4}$	2	$2\frac{1}{8}$	$2\frac{3}{8}$	$3\frac{1}{8}$	$3\frac{1}{4}$
	4.—Butts and edges of inner bottom plating	4	$1\frac{1}{4}$	$1\frac{1}{8}$	$1\frac{3}{4}$	2	$2\frac{1}{8}$	3	$3\frac{1}{8}$	4
	5.—Longitudinal seams of the shell plating forward and aft: seams and butts of bulkhead platiug: upper deck stringer angles	$4\frac{1}{8}$	$1\frac{3}{8}$	$1\frac{5}{8}$	2	$2\frac{1}{4}$	$2\frac{3}{4}$	$3\frac{3}{8}$	4	$4\frac{1}{8}$
	6.—Bulkhead frame bars when caulked: keel angles: bar keels	5	$1\frac{1}{8}$	$1\frac{7}{8}$	$2\frac{1}{8}$	$2\frac{1}{8}$	$3\frac{1}{8}$	$3\frac{3}{4}$	$4\frac{3}{8}$	5
	7.—Frames: reverse frames: floors: keelsons: beams. bulkhead stiffeners	7	$2\frac{1}{4}$	$2\frac{1}{8}$	3	$3\frac{1}{4}$	$4\frac{1}{8}$	$5\frac{1}{4}$	$6\frac{1}{4}$	7
Number of rivets per row in edges of shell plating between frames amidships, not including frame rivets.	Maximum spacing	$4\frac{1}{2}$	$1\frac{3}{8}$	$1\frac{1}{8}$	2	$2\frac{1}{4}$	$2\frac{3}{4}$	$3\frac{3}{8}$	4	$4\frac{1}{8}$
	Frame spacing. 15 inches	..	11	9	8	6	5	..	..	..
	" " 16 "	..	12	10	8	7	5	..	..	..
	" " 17 "	..	..	10	9	7	6	..	..	..
	" " 18 "	..	.	11	9	7	6	5	..	..
	" " 19 "	..	..	.	10	8	6	5	..	..
	" " 20 "	..	..	.	..	8	7	5	..	..
	" " 21 "	..	..	..	..	..	7	6	5	..
	" " 22 "	..	..	..	..	..	7	6	5	5
	" " 23 "	..	..	..	..	..	..	6	5	5
	" " 24 "	..	..	..	..	..	..	7	6	5

ENGINEERING SPECIALTIES.

Improved Condenser Apparatus.

This surface condenser, designed for maintaining a high vacuum, has been placed upon the market by the C. H. Wheeler Condenser & Pump Company of Philadelphia, and is fitted with



a Mullan crank and fly wheel suction valveless air pump. The condenser is of the series parallel type, in which the steam enters the top group of tubes, passes by means of one header into the middle group, and thence through the other header into the lower section and finally out. With this arrangement, the hottest steam comes into contact with surfaces cooled by the coldest water, and in turn permits of the condensed steam or feed water being discharged from the air pump at the highest temperature possible, or within a few degrees of temperature corresponding with the tension of steam due to the vacuum in the condenser. The construction of the water chamber provides for the water's entering at the bottom of the condenser and discharging at the top of the

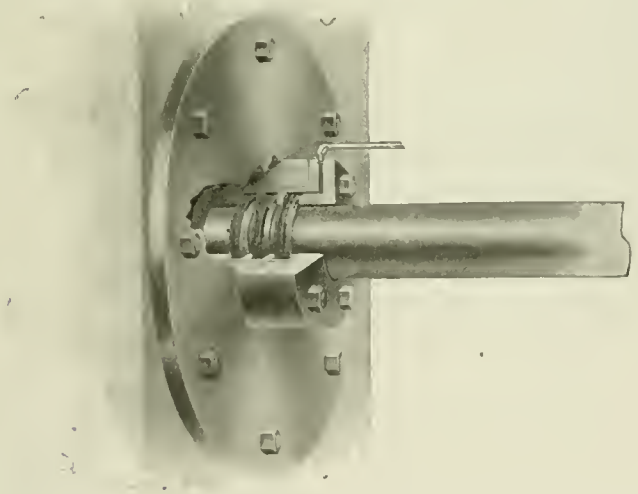
opposite chamber, this arrangement keeping the condenser filled with cooling water at all times.

The air cylinder of the air pump has a central port uncovered by the piston at each end of the stroke, but otherwise covered. The discharge valves are of the usual spring-seated poppet type, located at both ends of the cylinder. In shop tests these pumps have been operated within one-half inch of the barometric reading, and within two inches of absolute vacuum under full load operation, which provides means for insuring the best results with the modern steam turbine. The pumps are built either horizontal or vertical, to suit the needs of each particular case.

One of these sets was recently installed on the ferryboat *Edgewater* in New York harbor, displacing an ordinary surface condenser mounted with the old type of combined air and circulating pump. The old equipment had been in use about three years and gave a vacuum ranging under different conditions from 18 to 24 inches of mercury. The new equipment is said to have furnished a vacuum of from 27 to 28½ inches, with a corresponding reduction in fuel consumption of nearly 40 percent.

Metallic Packings.

It is seldom that a patent or invention reaches its highest point of efficiency while in the hands of the inventor. In other words, history would seem to demonstrate that a basic patent acts as a drag to progress until it has expired. An illustration of this is shown by the progress made with the Corliss valve gear since it has come into competitive manufacture. A very striking instance of this kind is shown in the manufacture of metal piston-rod packing. This was for years in the hands of people who were satisfied to manufacture in a small way, charging an exorbitant price for their product, and seeming to depend more upon chance than on knowledge for their success. A party of mechanical engineers and users of metal packing, having conceived the idea of making it on mechanical



principles, soon discovered that this product was peculiarly amenable to ordinary common sense. This success brought them to the attention of the Garlock Packing Company, Palmyra, N. Y., who at once arranged to take control of the product.

The demands of marine service seem to have received very careful consideration from these people. The style of metal packing heretofore used on marine work has been very difficult to place on bottom rods of vertical engines, and many an engineer has been tempted to "say things" when the entire contents of the stuffing box fell into the bilges just when the job was all done. This danger is said to be entirely obviated in their marine type, as is also the excessive and irregular wear of rod caused by other types with heavy band springs. These packings are made with split case, and can be applied or removed at any time without disturbing any part of the engine; arrangements are made for drainage of water, and the packing is guaranteed to withstand any water shock that can be safely put on the engine. There is no babbitt metal, fibrous or similar substance used, and the whole appears to be a mechanical problem worked out to its logical finality.

TECHNICAL PUBLICATIONS.

Electric Wiring, Diagrams and Switchboards. By Newton Harrison, E. E. Size 5 by 7½ inches. Pages 272; figures 105. New York, 1906. Norman W. Henley Publishing Company. Price $1.50.

A thoroughly practical treatise covering the subject of electric wiring in all its branches, the book includes explanations of diagrams which are thoroughly explicit, and take care of everyday problems, with methods of obtaining the best results. The work is very simply written, requiring no greater knowledge of mathematics than that included in arithmetic, and the entire theory worked out simply from a statement of Ohm's law, covering the resistance of a circuit. The fundamental principle of drop of potential in circuits is shown, and circuits covering complete house wiring connections in examples are clearly illustrated. A few facts concerning testing are included, together with some information about lighting and conduit work. The book appears to be a very handy and comprehensive volume, and well fitted for the needs of the lineman, foreman and contractor.

Die Schiffsschraube. By Albert Achenbach, Marine Engineer in the Royal Technical High School at Kiel. Size 6½ by 9½ inches. Pages 84; plates 25. 1906, Kiel. Robert Cordes, Publisher. Price 10 marks.

This, the first of three sections of the work, covers the development and graphical representation of screws for ships, and gives a good insight into the conditions governing the development of the form of the blades on the drawing board. The first chapter, which is prefaced by a bibliography, covers the geometrical theory of the subject, and is followed by chapters showing respectively the chronological development of screw propellers; the construction of pitch triangles for propeller blades; the measurement of pitch and determination of mean pitch; the representation of blades of propellers in both projected and developed forms; the preparation of drawings for screws, and special forms of propellers.

The work, which is in German, is of very comprehensive character, and of course covers propellers of both uniform and variable pitch, the variation being both radial and from the leading to the following edge of the blades. In some places the calculus is used in the development of the theory, although in general dependence is placed upon trigonometry alone. The plates are all separate from the text, and are so fitted that they may be entirely opened up outside the text for ready reference back and forth. The work gives evidence of being a very valuable one, and we look forward with considerable anticipation to the other two sections.

Machine Shop Arithmetic. Fourth Edition. By F. H. Colvin and W. L. Cheney. Size 4 by 5¾ inches. Pages 144; figures 9. New York, 1905. The Derry-Collard Company. Price 50 cents.

The continued demand for a simple presentation of the problems coming before the man in the shop has made it necessary to issue a fourth edition of this work, which fact is in itself a good indication of the favor which it has met. The problems are presented in a clear and concise manner, and the book contains besides a number of tables of prime importance in the machine shop. Additions to previous numbers which appear for the first time in this edition include tables of metric threads and of force, shrink and running fits.

The Senate on February 14 passed the Ship Subsidy bill by a vote of 38 to 27. The House comes next.

QUERIES AND ANSWERS.

All reasonable questions concerning marine engineering received from and signed by subscribers will be answered by the Editor in this column. All communications must bear the name and address of the writer.

Q. 329.—Would you please tell me in your Queries how to line up a beam engine. W. M. F.

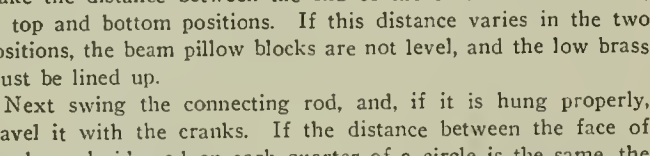
A.— Run a line through center of cylinder to top of slides. Try the slides with gauges thwartship, and with straight edges, and if they are not too far out of line they can be brought to position by screwing up on the brace nuts. The beam should be brought to a horizontal position, and the cylinder end placed exactly in the center between the slides. Then run a line down from the fork end of connecting rod journals on the other end of beam, so that it will pass through the center of the space between the cranks at the shafts. This line should then be sighted with the line in the cylinder. If they are in one plane the beam is straight fore and aft; if not, it must be swung straight by shifting its pillow blocks. Next move the beam up and down so that the crosshead (with the jaws and gibs off) travels between the slides. Take the distance between the end of the crosshead and slides, in top and bottom positions. If this distance varies in the two positions, the beam pillow blocks are not level, and the low brass must be lined up.

Next swing the connecting rod, and, if it is hung properly, travel it with the cranks. If the distance between the face of cranks and side rod on each quarter of a circle is the same, the shafts are in line with the beam. The cheek pieces should be removed from the eye of the drag crank during this operation, in order to leave the crank pin perfectly free. Care should first be taken to ascertain whether the two shafts are in line. This is done by noting the position of the crank pin in the eye of the drag crank in successive crank positions of travel.

SELECTED MARINE PATENTS.

805,688. MEANS FOR STOPPING THE MOTION OF VESSELS. EUGENE P. A. VILLETTE, LILLE, FRANCE.

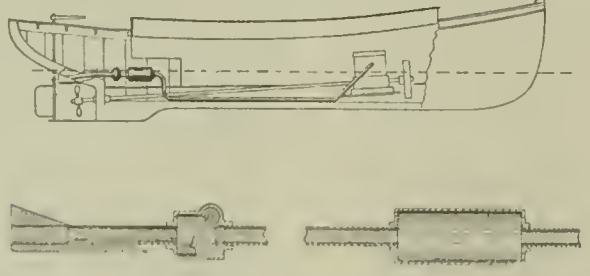
Claim.—1. In apparatus for quickly stopping vessels in movement, plates consisting of two sections telescoping into each other when at rest and



arranged vertically in zigzag form and in group along the length of the hull of the vessel; the inner section having projections and the outer one stops to limit the movement of the interior one; and the outer plates having projections adapted to abut against the wall of the hull for the same purpose. Two claims.

806,083. MUFFLER FOR INTERNAL-COMBUSTION ENGINES. FRED J. GOWING, SACKET HARBOR, N. Y., ASSIGNOR OF ONE-HALF TO JEROME B. ROSEBOOM, SACKET HARBOR, N. Y.

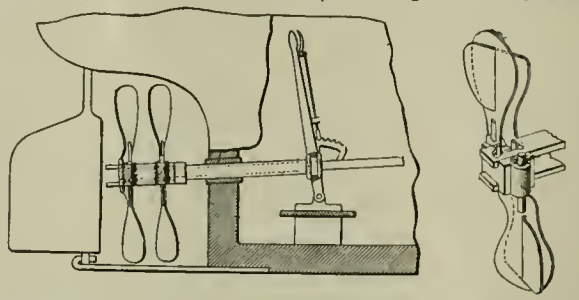
Claim.—1. In a muffler of the class described, the combination with a boat or other water craft, and an engine to operate the same mounted



thereon, of a pipe adapted at one end to receive the exhaust from said engine, a drum or like part connected with said exhaust pipe, an extension pipe, a check valve connected with said extension pipe, and a nozzle adapted to discharge the exhaust from said engine beneath the surface of the water. Five claims.

807,498. SPEED-CONTROLLING REVERSING-PROPELLER. CHARLES F. ROPER, HOPEDALE, MASS.

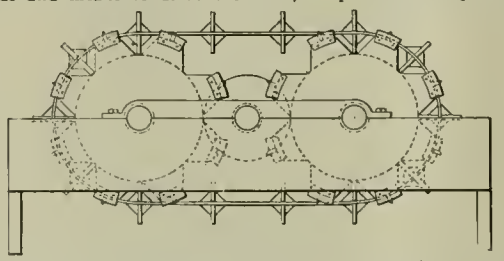
Claim—1. A shaft adapted to be rotated in one direction at a substantially uniform speed, a propeller mounted thereon, comprising two sets of angularly-movable blades, and means to vary the angularity of the blades of the sets and to vary the relative angularity of the blades of the two sets by a differential movement of such blades, the change in the angularity of



the blades effecting a variation in the force of propulsion, and also serving to reverse the direction thereof, while the differential movement causes the blades to maintain a substantially constant resistance on the motor. Ten claims.

805,871. PROPELLER. FRANCIS W. McCAIN, MIDWAY, W. VA.

Claim.—1. In a propeller for vessels, the combination with flexible metal bands and means to drive the same, of paddles having at the ends



slots at the median line through which the bands extend, straps extending around the ends of the paddles and fastened to the bands, and braces between the straps and bands. Two claims.

Lloyd's Register of British and Foreign Shipping has issued a summary of shipbuilding for the year 1905, the figures being given in much detail. Without going into extensive particulars, we will state simply that the merchant shipping launched in the United Kingdom consisted of 795 ships of an aggregate of 1,623,168 gross tons, which is practically 100,000 tons greater than in the previous record year of 1901. The figures include vessels of over 100 tons only.

In France the tonnage launched was 73,124; in Germany, 255,423; in Italy, 61,629; in Holland, 44,135; in Norway, 52,580. These figures compare with a total of 302,827 tons in the United States, represented by 200 vessels of upwards of 100 tons, 60 percent of the tonnage having been on the Great Lakes.

The total launchings outside of Great Britain amounted during the year to 781 vessels of above 100 tons each, with an aggregate of 891,754 gross tons. This makes the world's shipbuilding during the year 1,576 vessels amounting to 2,514,922 gross tons. In addition to this there were 118 warships launched, of an aggregate of 363,211 tons displacement.

The Bureau of Navigation reports that there were constructed in the United States during the month of January, 61 sail and steam vessels of an aggregate of 11,720 tons. To this magnificent total the Great Lakes contributed one ship, *Frank C. Ball*, of 6,909 tons, or more than half the aggregate tonnage. It will be seen that the remaining ships have an average size of 80.3 tons. Of the total, only three ships were of steel, the two on the coast aggregating less than 400 tons, or an average of less than 200 tons each.

The Bureau of Navigation reports that during the six months ending December 31, 1905, there were constructed in the United States 542 vessels of a total of 136,097 gross tons, this making a total for the year of 1,054 vessels of 306,563 tons. In the six months covered the construction of steel steamers amounted to 51 vessels of 100,127 tons, of which 21 vessels aggregating 80,932 tons were accounted for by construction on the Great Lakes. The average size of all the vessels included in the total for the six months figures out at 251 tons. The steam vessels built of steel averaged 1,961 tons, while the ships on the Great Lakes included under the latter heading averaged 3,853 tons.

Marine Engineering

APRIL, 1906

FRENCH ARMORED CRUISERS.

BY J. PELTIER.

Since 1898 there have been completed for the French navy thirteen armored cruisers, which may be divided into five types: Three units of 7,700 tons; three of 9,500 tons; five of 10,000 tons; one of 11,300 tons; and one of 12,500 tons. In addition to these, there are under construction three additional cruisers of 12,500 tons and three of 13,600 tons. The particulars of these six types of cruisers will be found given in the table, which covers all of the leading items of information with regard to dimensions, power, speed, battery, protection and steaming radius.

The *Leon Gambetta*, which is the first of the 12,500-ton cruisers to be placed in service, made a trial speed of 23.1 knots as an average for three hours, during which time the indicated horsepower averaged 29,008, with a maximum of 30,500. The Admiralty coefficient at this speed figures out as 230. A twenty-four-hour trial at three-fourths the full power resulted in 16,990 indicated horsepower and a speed of 20.4 knots, which corresponds with an Admiralty coefficient of 271. A twenty-four-hour coal consumption trial gave a speed of 20.1 knots with 16,600 horsepower and an Admiralty coefficient of 265. In this trial the coal consumption per indicated horsepower per hour figured out at 0.772 kilogram, or 1.7 pounds.

THE FRENCH ARMORED CRUISER LEON GAMBETTA, OF 12,600 TONS.

This ship has two protective decks, the lower one of which reaches 4 feet 7 inches below the mean load waterline, and is connected with the lower edge of the armor belt. The upper protective deck is 7 feet 6 inches above the waterline, being at the top of the heavy side armor, which has a width of 12 feet 1 inch and a thickness of 6.7 inches. This thickness is reduced at the lower edge and is also reduced at the ends of the ship, at which points it is only 3.5 inches. The upper part of the armor belt has a thickness of five inches amidships and 2 inches at the ends. The belt is carried across near the stern by a bulkhead situated abaft the rudder post, and the extreme stern is unprotected by side armor. There are two other armor bulkheads on the ship, one of them being just abaft the forward barbette and the other just before the after barbette. These bulkheads have a thickness of 4.8 inches and extend from main deck to spar deck, thus protecting the 'tween decks from a raking fire. The whole of the belt armor is laid on a backing of teak, and water excluding material is packed in a cofferdam behind the armor and backed up by a watertight longitudinal bulkhead. The thickness of the lower armor deck varies from 2.2 inches to 1.8 inches, while the upper armor deck has a thickness varying from 1.3 to 0.8 inches.

The battery of this ship includes four guns of 7.7 inches; sixteen of 6.4 inches in caliber; twenty-two 3-pounder rapid fire guns and five torpedo tubes, of which two are submerged. This is so disposed that the fore-and-aft fire consists in two 7.7-inch guns and six 6.4-inch guns, while there may be concentrated on either broadside four of the former and eight of the latter. The 7.7-inch guns are mounted in pairs in closed barbettes forward and aft, and twelve of the 6.4-inch guns are similarly mounted in pairs in turrets on the spar deck, the other four being in casemates. Of the 3-pounder guns, six are on the upper armored deck, ten on the main deck and six on the bridges.

The protection for the heavy turret guns consists in armor with a thickness of 7.9 and 5.5 inches respectively, while the casemates inclosing four of the 6.4-inch guns have walls of a thickness of 4.7 inches with 1-inch splinter bulkheads, 1-inch

Owner.	France.			France.			England.	
Name.	Desaix, Kleber, Dupleix.	Montcalm, Amiral Gueydon, Dupetit Thonars.	Gloire, Condé, Sully, Amiral Aube, Marseillaise.	Jeanne d'Arc.	Leon Gambetta, Jules Michelet, Jules Ferry, Victor Hugo.	Ernest Renan, Waldeck Rousseau, Edgard Quinet.	Drake.	Natal.
Normal displacement, tons...	7,700	9,515	10,014	11,300	12,606	13,644	14,100	13,550
Length at waterline, feet....	426′ 6″	452′ 9″	452′ 9″	475′ 9″	487′ 4″	515′ 1″	500′	480′
Extreme breadth.....	58′ 7″	63′ 7″	66′ 2″	63′ 7″	70′ 2″	70′ 1″	71′	73′ 6″
Astern draught.....	24′ 4″	24′ 7″	24′ 9″	26′ 7″	26′ 10″	26′ 10″	26′	27′
Horsepower.....	17,100	19,600	20,500	28,500	29,000	36,000	31,700	23,500
Speed.....	21	21	21	21.7	22.5	24	24.3	22.5
Admiralty coefficient.....	211	212	210	181	213	219	261	275
Armor belt amidships	4″	5.5″	5.5″	5.5″	6.7″	6.7″	6″	5.5″
Armor belt forward, aft	2.2″ 0	2.2″ 2.2″	3″ 3″	2 2″ 2 2″	3.4″ 3.4″	3.4″ 3.4″	2″	4″ 3′
Armor belt, upper strake.....	....	3.5″	5″	2 8″	5″	5″	4.7″	5.5″
Armor bulkheads.....	4″	4.5″	4.5″	4.5″	4.5″	4.5″	4.7″ 8″	6″
Armor barbettes.....	7.5″	7.5″	7.5″	7.5″	7.5″ 5.2″	7.5″ 5.2″	6″	5.5″
Armor turrets and casements.	....	4.5″	4.5″	4.5″	4.5″ 4″	4.5″ 4″	5″	4″
Lower protected deck	1.7″ 2″	1 1″ 2″	1.7″ 2″	1.1″ 2″	1.8″ 2 2″	1.8″ 2.2″	2″ 3″	2.5″ 1″
Upper protected deck	1.1″	1.1″	1.2″	1.1″	0 8″ 1.3″	0.8″ 1.3″	....	.....
Conning tower.....	6″	6″	7.5″	7.5″	7.5″	7.5″	12″	9 5″
Battery.....	10 6.4″	2 7.7″	2 7.7″	2 7.7″	4 7.7″	4 7 7″	2 9.2″	6 9.2″
	4 3.9″	8 6 4″	12 6.4″	8 5.5″	16 6.4″	16 6.4″	16 6″	4 7.5″
	10 3-pdr.	4 3 9″	4 3.9″	10 3 9″	22 3-pdr.	28 3-pdr.	14 3″	20 3-pdr.
	6 1-pdr.	16 3-pdr.	18 3-pdr.	16 3-pdr.	....	....	3 3-pdr.	.....
	....	6 1-pdr.	6 1-pdr.	...	....	....	....	.....
Torpedo tubes.....	2	2 (sub.)	5 (2 sub.)	2 (sub.)	5 (2 sub.)	5 (2 sub.)	2 (sub.)	3 (sub.)
Coal (nominal—bunker capacity).....	880–1,200	1,020–1,920	1,520–2,000	1,400–2,100	1,400–2,100	....	1,250–2,580	1,000—(?)
Steaming radius at 10 knots	6,450–8,800	6,500–10,800	6,500–10,300	9,000–13,500	12,000	....	at 19 knots.	.....
Steaming radius at 21 knots..	1,210–1,650	1,230–1,890	1,230–1,890	1,250–1,700	1,500 at 22 kn'ts	....	2,150–4,300	.....
Crew.....	480	562	525	605	700	800	900	804

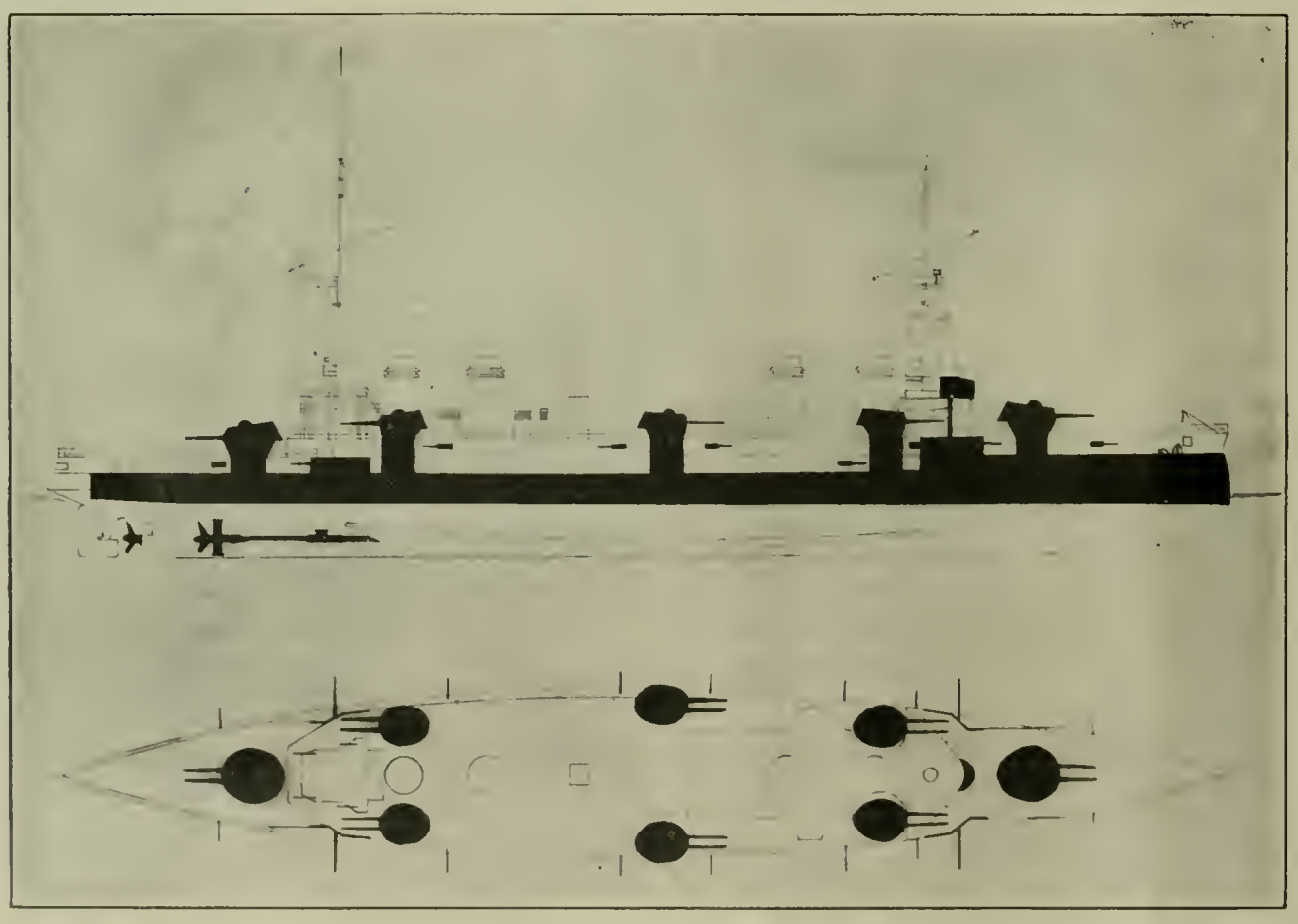


DIAGRAM OF LEON GAMBETTA, SHOWING DISPOSITION OF GUNS AND ARMOR.

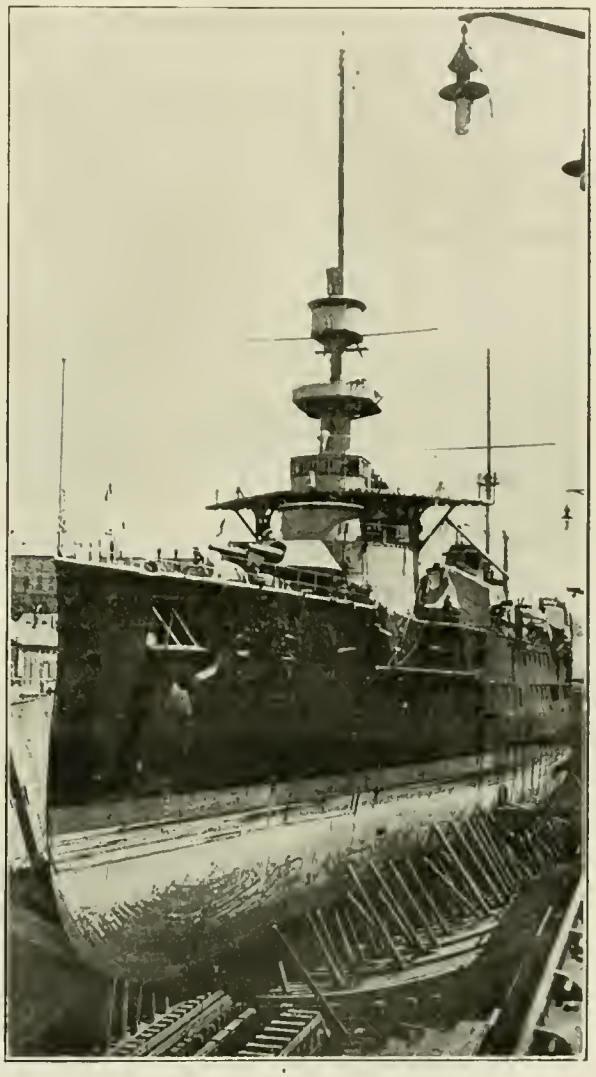
ceiling and 1.2-inch floor plates. These casemates are really continuations of the side armor, which makes it impossible for them to be destroyed by cutting away the underpinning, as is the case in many constructions.

The ship is driven by three screws actuated each by a separate four-cylinder, triple-expansion engine with piston diameters 39-inch, 59-inch and two each of 65-inch, and a common stroke of 37 inches, and operating at 125 revolutions per minute. These engines are located amidships between the sets of boilers. The latter, twenty-eight in number, are of the Niclausse type, with a total grate surface of 970 square feet, and operate at a pressure of 216 pounds per square inch. Each set of fourteen boilers

Germany.	Italy.		United States.	
Friedrich Karl.	Roma.	Amalfi.	California.	Tennessee.
9,050	12 625	9.864	13.680	14 500
413′ 5″	474′ 2″	427′	502″	502″
65′ 7″	73′ 5″	68′ 9″	69′ 6″	72′ 10″
24′ 3″	27′ 2″	23′ 6″	24′ 1″	25′
17.000	20,000	18.000	26 800	23 000
21	22	22.5	22.3	22
237	288	287	237	275
4″	10″	7.8″	6″ 5″	5″
3″ 3″	4″ 4″	?	3″ 3″	2.8″ 2.8″
4″	8″	7.1″	4″	4″
4″	7.5″	?	4″	4″
6″	8″	?	6″	7″ 4″
6″ 3″	6″ 3″	?	6.5″ 6″	9″ 7″ 5″
2″ 1.5″	4″ 1.5″	?	4″ 1.5″	4″ 1.5″
....	....	....	....	.....
6″	10″	7.8″	8.5″	8.5″
4 8.2″	2 12″	4 10″	4 8″	4 10″
10 5.9″	12 8″	8 8″	14 6″	16 6″
12 3.4″	12 4″	16 3″	18 3″	22 3″
10 1-pdr.	12 3-pdr.	8 3-pdr.	12 3-pdr.	12 3-pdr.
....	....	....	....	.....
4 (3 sub.)	4 (2 sub.)	3 (1 sub.)	2 (sub.)	4 (sub.)
950-1,500	1,000–2,800	700-1,500	900–2,024	900–2,014
5,000	10,000	....	....	.....
....	....	....	....	.....
624	750	....	790	810

is served by two funnels measuring 65 feet above the grate bars. The maximum speed obtained during the trial runs over the measured mile was 24 knots, which required 30,500 horsepower. Several other individual runs go as high as 23.6 knots. The consumption of fuel is such that with the total bunker capacity of 2,100 tons of coal, the steaming radius at 11 knots figures out at 12,000 nautical miles, and 1,500 miles at 22 knots. In addition to the coal supply, provision is made for carrying 100 tons of liquid fuel. The normal bunker capacity is 1,400 tons.

Ventilation of all compartments below the protective deck is taken care of by means of electric fans, fresh air being drawn in through ducts located between the funnels. Bilge pumps are fitted, with a total hourly capacity of 700 tons of water. Electricity is used to a considerable extent not only for lighting but for certain of the auxiliary machinery, turret turning, ammunition hoists, steering gear and fans. There are six searchlights, two being fitted forward and two aft, and one on each mast.



BOW VIEW OF GAMBETTA IN DRY DOCK.

ARMORED CRUISER GLOIRE, OF 10,014 TONS.

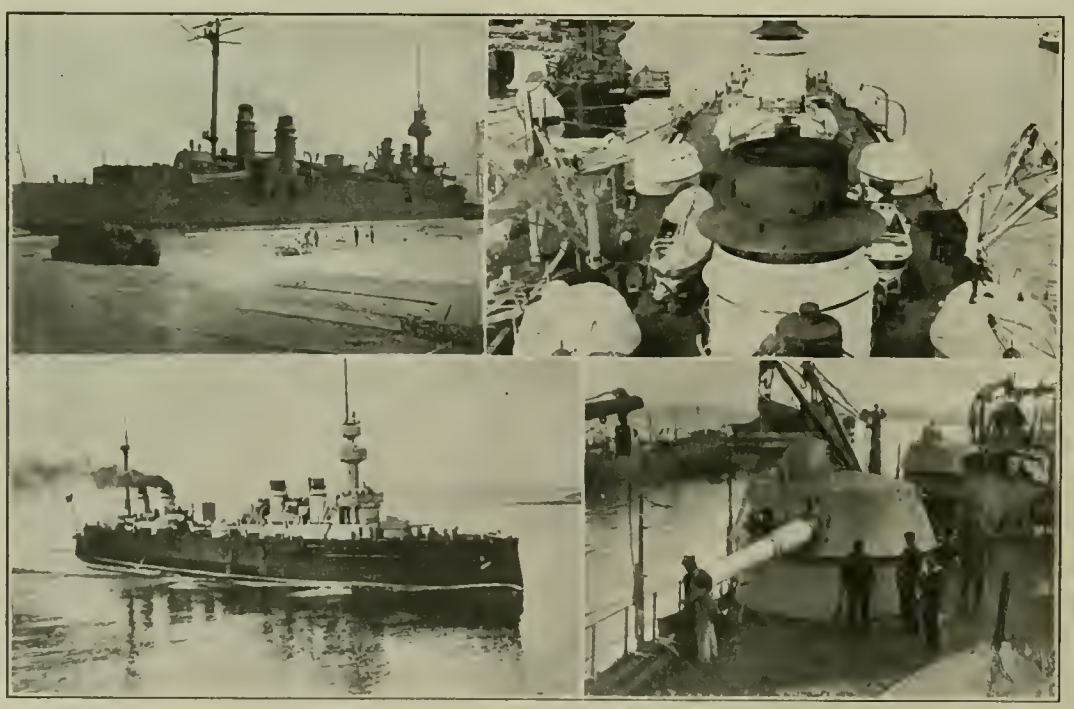
Electricity is generated by means of four dynamos, three being required for constant service, while the fourth is in reserve.

The ammunition hoists carry ammunition for the 7.7-inch guns from magazines directly beneath the barbettes. Other ammunition is stored in rooms between the main engine rooms and the boiler rooms.

Taking the ship as a whole, she forms an interesting solution of the problem of condensing in a moderate displacement high speed, powerful artillery, good protection and a satisfactory steaming radius. She represents the resultant of improvements indicated by experience with previous types, and has got away from the bad features incident to the early attempt to include much the same military qualities in a vessel of 7,700 tons. In these small ships the engines are fragile, the hull weak and the cost of keeping the ship in good repair overbalances the difference in first cost which would have been required for better and larger constructions.

The *Leon Gambetta* is known as a vanguard cruiser, having all the necessary qualities to search for the enemy and to keep in contact with him; her speed and small artillery insure her against successful attack by destroyers, while her protection and heavy artillery make her able to fight on equal terms against similar cruisers in foreign navies, and momentarily with a battleship. It would be impossible, however, for her to long sustain an engagement with such a powerful antagonist, because of the fact that her superstructure would be destroyed in a very short space of time, and with such effect as probably to nullify all attempts to supply the turrets and guns and keep them in working order. Not only this, but the destruction of the base of the funnels would fill the upper works of the ship with smoke and hydro-carbon gases from the fires, rendering asphyxiation extremely likely. This would also operate to neutralize the effect of forced draft, and thereby cut down the speed.

The second part of the table deals with similar cruisers of about the same sizes in foreign navies. One of these ships, the *Roma*, is usually called a battleship, but her speed is such that she properly comes under the classification known as "battle cruisers" which represents what may be expected to be in some measure the ultimate outcome of the present approachment in type between the battleship and the armored cruiser.



ARMORED CRUISER AMIRAL AUBE, OF 10,014 TONS.

Steam Tug for Argentina.

The accompanying illustration shows the steam tug *Poderoso*, recently completed by Messrs. J. Thornycroft & Co., Southampton.

ARGENTINE TUG PODEROSO.

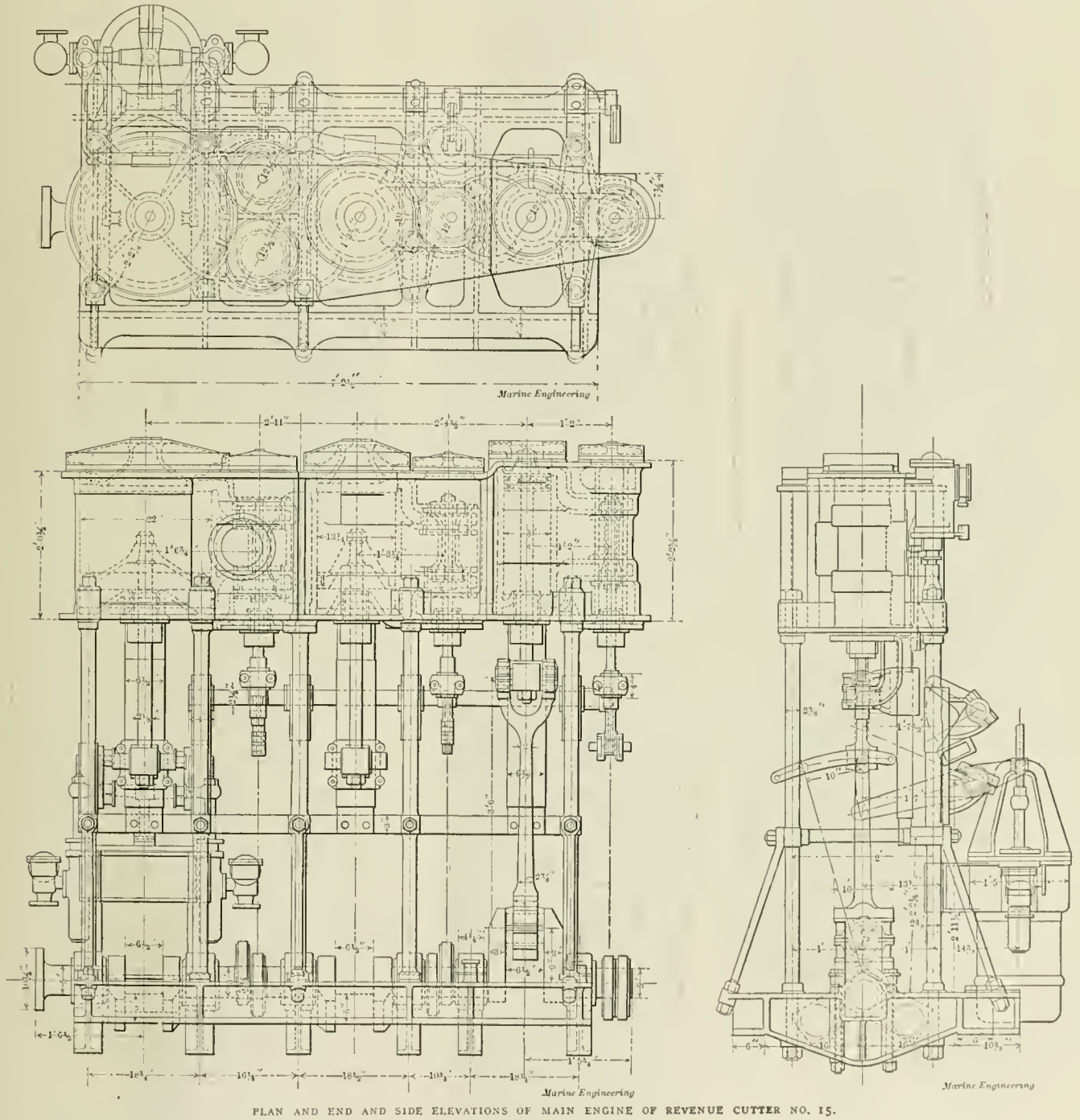
The order for this vessel was placed on July 20, the firm being under a guarantee to deliver the boat in twelve weeks from receipt of order. The tug was built, launched and officially tried in eleven weeks, and left for Buenos Aires under its own steam.

The dimensions of this single-screw tug are as follows: Length between perpendiculars, 75 feet; breadth molded, 18 feet; depth, 9 feet 3 inches.

She is fitted with a compound surface condensing engine and return tube boiler, the cylinders being 15 and 30 inches in diameter by 22 inches stroke. The boiler is 10 feet 6 inches in diameter by 10 feet long.

A NEW SHALLOW DRAFT REVENUE CUTTER.

For use on Albermarle and Pamlico sounds in North Carolina there has been designed a revenue cutter (No. 15) of about 408 tons cruising displacement, which is to make a speed of twelve miles per hour, with twin screw engines developing 600 horsepower. Advertisements have been issued for bids for this steamer, which will be placed in service as soon as it can be constructed.



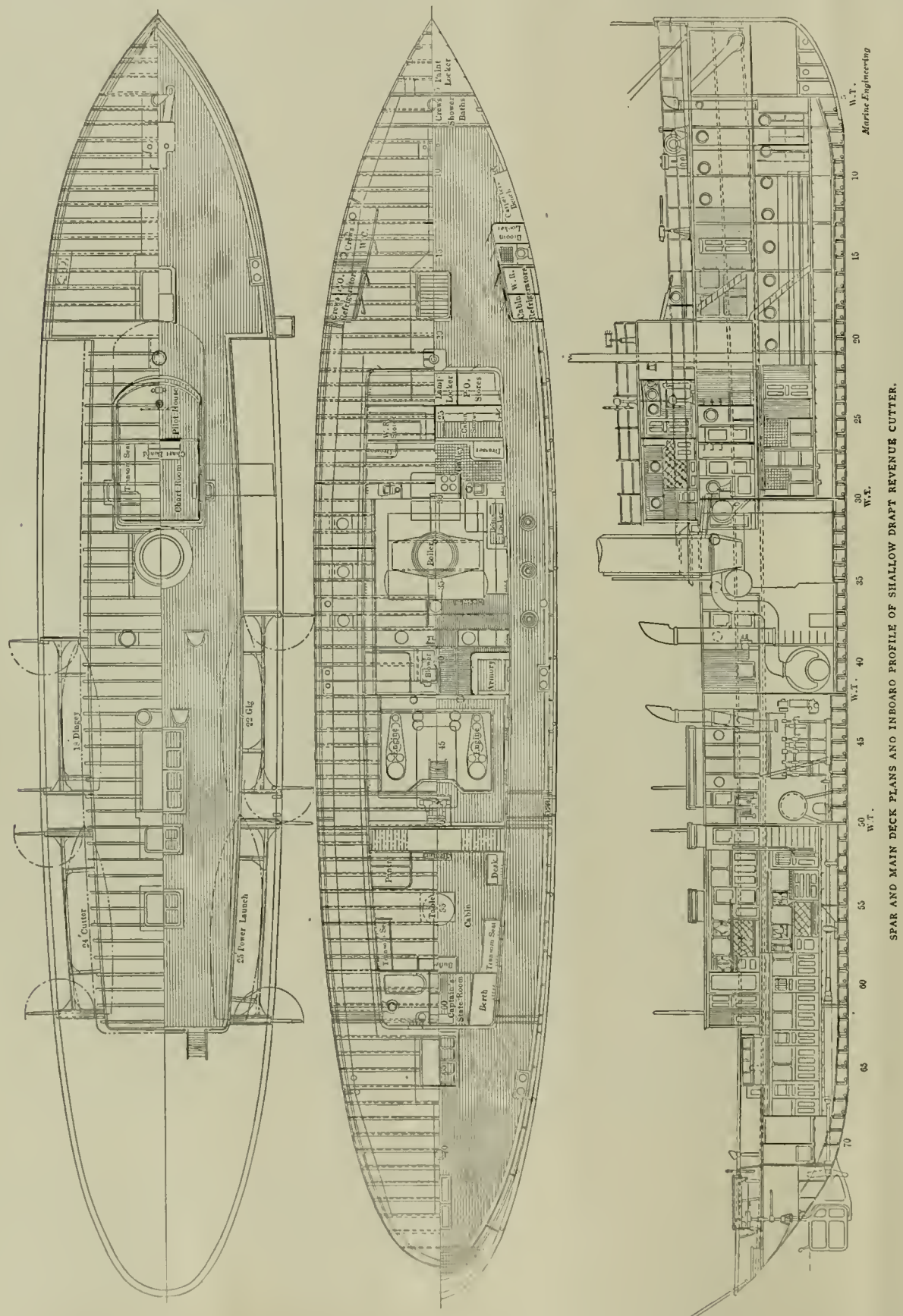
PLAN AND END AND SIDE ELEVATIONS OF MAIN ENGINE OF REVENUE CUTTER NO. 15.

THE HULL.

The length over all is 158 feet, length between perpendiculars 148 feet, breadth molded 30 feet, depth from base line at side 10 feet, and draft of water with normal supplies on board 5 feet. This corresponds, as above, to a displacement of 408 tons, and includes loads of 25 tons of coal and 2,400 gallons of fresh water. The total capacity for coal and fresh water are respectively 47 tons and 8,200 gallons. At the 5-foot load water line, the area of immersed midship section is 143.54 square feet, corresponding with a coefficient of 0.957; the area of the immersed longitudinal plane is 693.46 square feet; the area of the water plane is 3,345 square feet, corresponding with a coefficient of 0.735; the block coefficient is 0.644; and the area of wetted surface is 4,366 square feet. The additional displacement corresponding with added immersion of one inch, is 7.96 tons. The center of gravity of the ship under normal conditions when drawing 5 feet of water is 7 feet 11 inches above the base line, or 2 feet 11 inches above the water line, and is 3 feet ½ inch aft of frame 36.

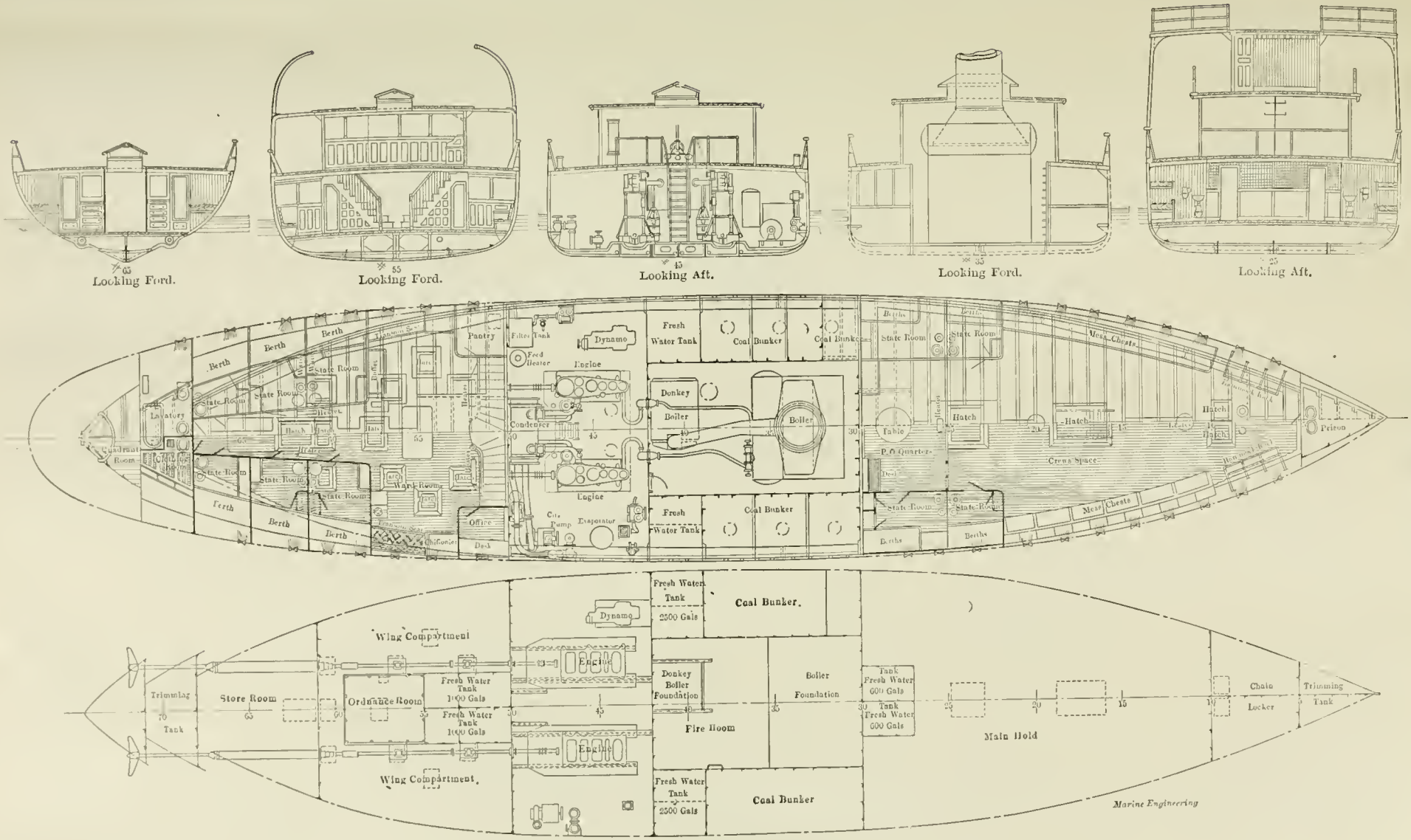
The keel is of the flat plate type, measuring 27 inches wide and 17 pounds thick, and is fitted in lengths of about 18 feet, with butt straps of 20 pounds treble chain riveted. A vertical keel is fitted inside with a thickness of 14 pounds and a depth of 17⅜ inches, extending 3¼ inches above reverse bar angles in order

to afford connection to two continuous longitudinal angles, 3½ by 2½ inches by 5 pounds. Continuous longitudinal angles



SPAR AND MAIN DECK PLANS AND INBOARD PROFILE OF SHALLOW DRAFT REVENUE CUTTER.

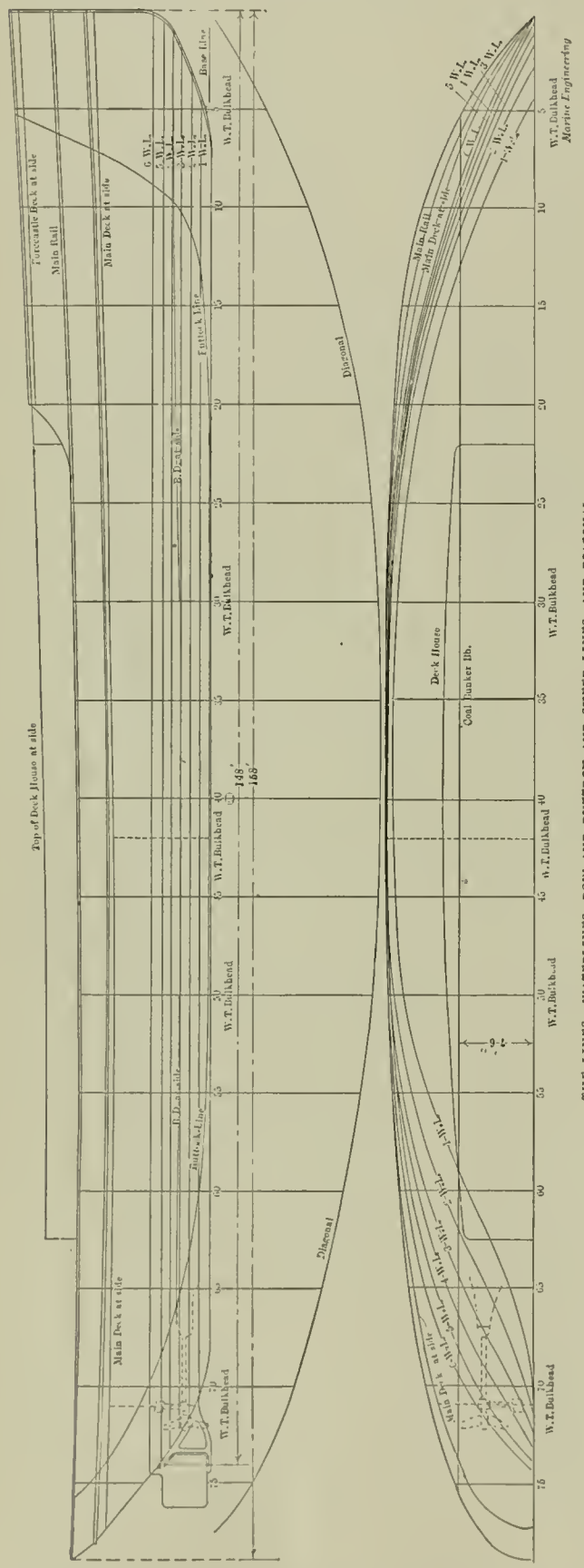
at its lower edge, 3½ by 2½ inches by 6 pounds, extend from stem to stern and connect it with the flat keel. Under the engine bedplate and thrust bearing this vertical keel is increased in depth to afford connection with same. Above the lower longitudinal bars are cut limber holes in this vertical keel, 3 inches in diameter, one in each frame space. The stem is of hammered iron 6½ by 1¼ inches, in one piece, and rabbetted to receive ends of outside plating. The stern frame is of cast steel in one piece, molded



PLANS OF BERTH DECK AND HOLD, AND FIVE TRANSVERSE SECTIONS OF REVENUE CUTTER.

6½ inches and sided 1¾ inches.

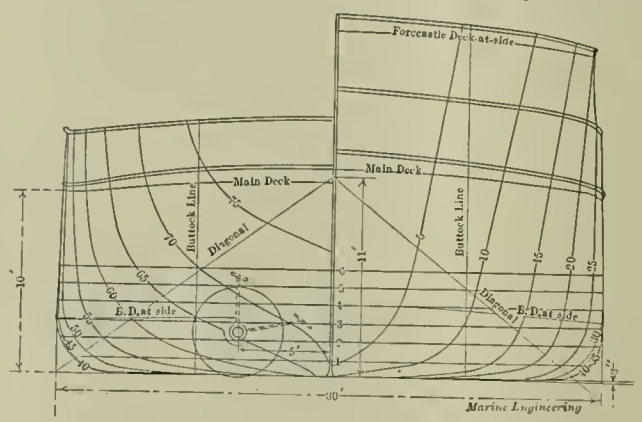
Transverse frames are spaced 24 inches between centers.



THE LINES—WATERLINES BOW AND BUTTOCK AND SHEER LINES, AND DIAGONAL.

From frame 20 to 55 they are 3 by 2½ inches by 5½ pounds; forward and aft the weight is 4½ pounds per foot. Under the engine are worked intermediate frames for local support. At transverse watertight bulkheads double angle bars of the same weight as midship frames are substituted for the regular frames. Reverse bars are fitted throughout, being 2½ by 2½ inches by 4 pounds amidships, and worked on alternate frames to underside of main deck stringer and 6 inches above upper bilge keelson. Forward and aft the weight is 3¾ pounds. In the engine and boiler spaces the reverse frames are doubled, one bar running to the main deck stringer plate and the other stopping at the turn of the bilge. The short bars pass through the vertical keel.

Floor plates are fitted amidships, 13 inches deep at the throat, and with a thickness of 12 pounds. The engine and boiler foundations are formed of floors with a weight of 14½ pounds per square foot, the depth being made suitable in each case. Forward and aft the floors are of 10-pound steel. All floors are lightened by holes, and are connected to the vertical keel with angle clips 3 by 2½ inches by 6 pounds joggled over reverse bars. Limber holes 4 inches in diameter are cut in all floor plates except at transverse watertight bulkheads. The floor forming the transom is 21 inches deep and 12½ pounds thick. Flat keelson plates are fitted, 6½ inches wide and 14 pounds thick,



BODY PLAN OF REVENUE CUTTER.

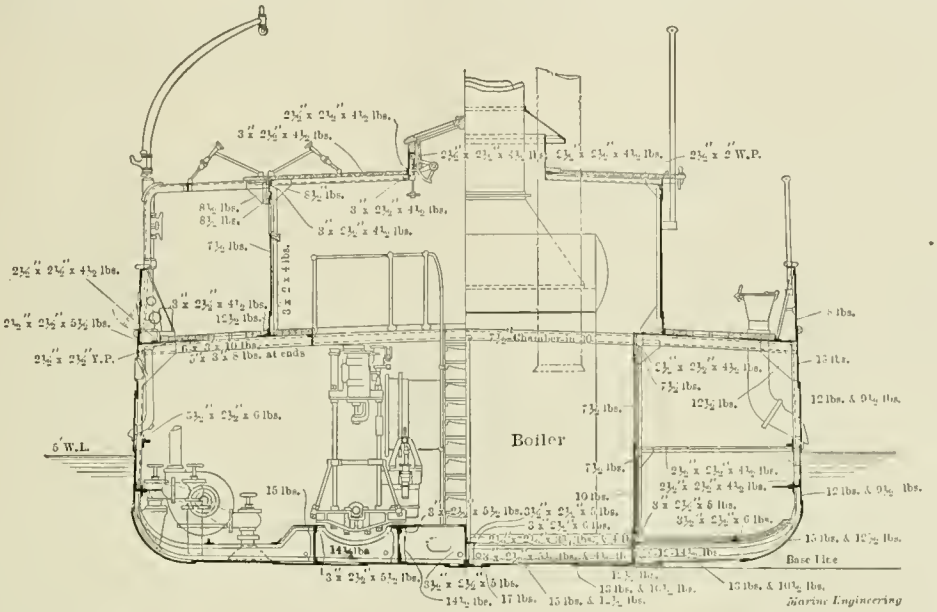
on each side of the vertical keel. extending from frame 5 to frame 71.

The main deck beams are bulb angles, with a spring of 7½ inches in 30 feet, and are fitted at every frame; they measure 6 by 3 inches by 10 pounds. At the extreme ends of the vessel the beams are reduced to 5 by 3 inches by 8 pounds. In the living spaces on the forward and aft berth decks the ends are split and turned down 15 inches, with a triangular piece welded in. In other parts of the vessel they are connected to the frames by bracket plates 7½ pounds thick. Berth deck beams consist of angle bars on alternate frames, and worked with a spring of 5 inches in 30 feet. At the sides of the vessel their tops are about 6 feet 9 inches below the tops of the main deck beams. They measure 3½ by 3 inches by 7½ pounds, and are connected to the frames and fore-and-aft bulkheads by 7½-pound bracket plates. Forecastle deck beams measuring 3½ by 2½ inches by 6.6 pounds are fitted at every frame aft of No. 5. Forward of No. 5 they are 3 by 2½ inches by 5½ pounds. All have a spring of 7½ inches in 30 feet, and have ends split and turned down 12 inches, with a triangular piece welded in the split.

One longitudinal is fitted on each side of the vessel, standing perpendicular to the outside plating throughout its length, and extending as far forward and aft as practicable. It is intercostal between the floors, and is made of 12½-pound plating. The upper edge extends above the reverse frame sufficiently to permit the securing to it of double continuous angles 3 by 2½ inches by 5 pounds. In the engine compartment there are substituted for this longitudinal two plates of 14½-pound steel, assisting in forming a foundation for the engine. Two keelsons are fitted on each side of the vessel, consisting in each case of double angle bars 3½ by 2½ inches by 6 pounds, and running as far forward

and aft as practicable. They are continuous, and are situated one above and the other below the turn of the bilge. In addition there is fitted a hold stringer, with double angle bars 2½ by 2½ inches by 4½ pounds.

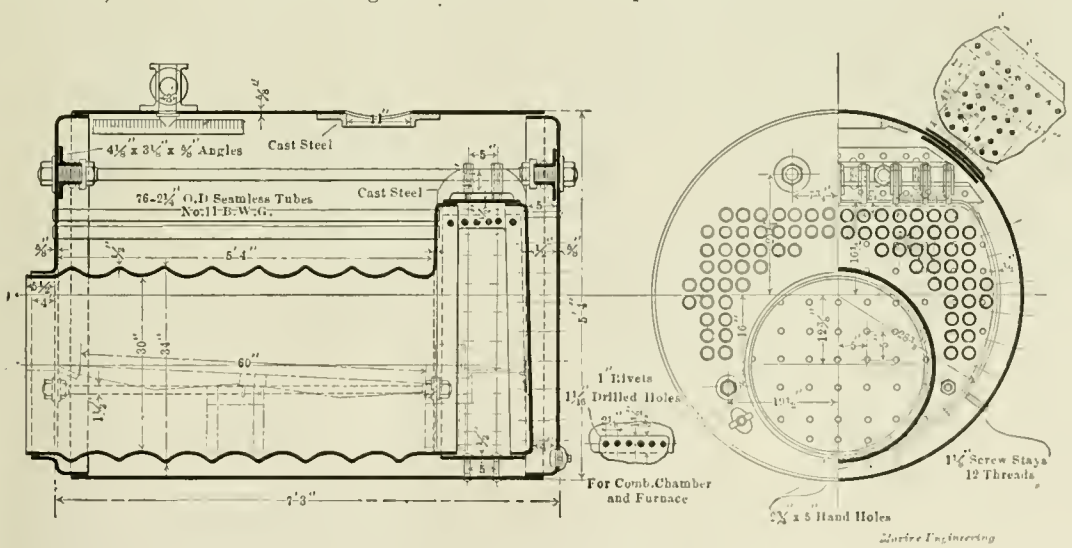
The main deck stringer plates amidships are 28 inches wide by 11½ pounds thick. Forward and aft the thickness is 9 pounds and the width is gradually reduced to 15 inches. This is worked



MIDSHIP SECTION, SHOWING SCANTLINGS.

in lengths of about 20 feet, with double chain riveted butts. Except on the forecastle deck, this is connected on the upper outboard side to the sheer strake by a continuous angle bar 2½ by 2½ inches by 5½ pounds. Under the forecastle deck intercostal angle bar clips of the same size are substituted. Continuous angles, 2½ by 2½ inches by 4½ pounds, are fitted to form a gutterway 10 inches in width, and to serve as backing for the deck plank. Tie plates 10 inches by 10 pounds are worked on each side of hatches under deck house and over coal bunkers. At the ends of decks and around mast 10-pound plate is fitted. Berth deck stringer plates 18 inches wide and 9 pounds thick are fitted amidships, the thickness being reduced to 7½ pounds at the ends of vessel. Plating 7½ pounds thick is fitted between stringer plates at ends. Tie plates 10 inches wide by 7½ pounds thick are also fitted. Forecastle deck stringers are 15 inches wide and 7½ pounds thick, with 7½-pound plating fitted between the stringers. Under the windlass, bitts, gun, around the mast and across the ends of this deck 8½-pound plates are fitted. On each side of hatches are tie plates 10 inches by 7½ pounds.

Transverse watertight bulkheads are located, as shown, at frames 5, 30, 42, 50 and 71. The bottom strakes are 8 pounds and the upper strakes 6½ pounds. They are stiffened by vertical angle bars 3 by 2 inches by 4.1 pounds, about two feet apart; the angles to the deep bulkheads in boiler and engine spaces being five pounds per foot. The collision bulkhead has plates 10½ pounds thick on the bottom strakes and 8½ pounds over the upper half, and in addition to the usual stiffening has horizontal angle bars of the same size on the opposite side, and spaced about 4 feet between centers. Similar horizontal stiffeners are fitted also to the deep bulkheads.



LONGITUDINAL AND TRANSVERSE SECTIONS OF AUXILIARY BOILER.

The foundations for the main engines are built up from the framing of the vessel, of which they form a part. Deep floors 14½ pounds thick are worked under engines, boilers and thrust bearings, and are stiffened longitudinally by intercostal plates of the same weight, secured to floors and cap plate of engine foundations by angle clips 3 by 2½ inches by 5½ pounds. The cap plate is of 15-pound steel.

Outside plating, aside from the keel, consists of garboard strakes 15 pounds amidships and 12½ pounds at the ends;

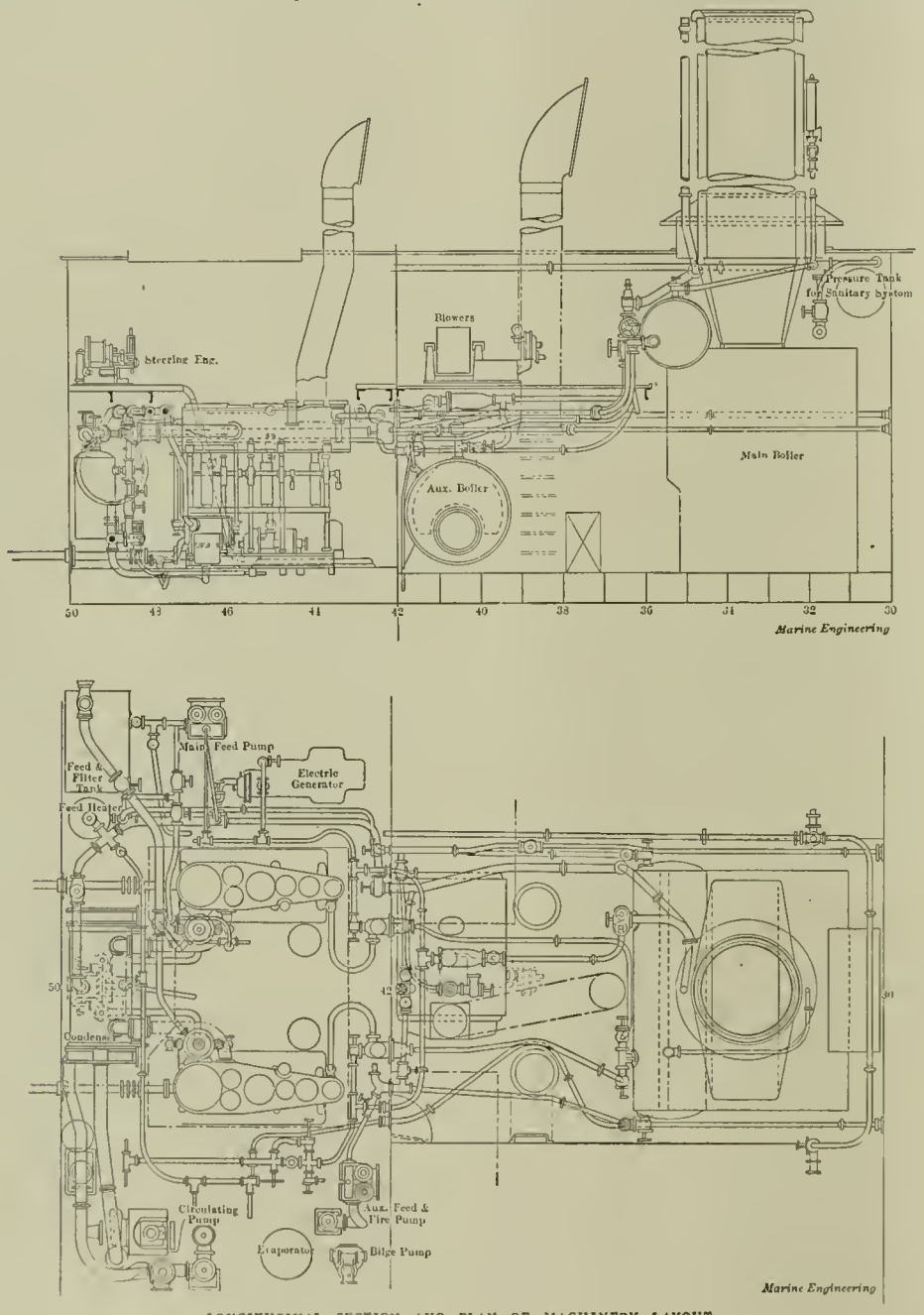
bottom strakes weighing 13 and 10½ pounds respectively; bilge strakes of 15 and 12½ pounds; and side strakes of 12 and 9½ pounds. The sheer strakes for the entire length are 30 inches deep and 18 pounds thick. Bulwark plating and forecastle sides are 8 pounds thick. All plates are fitted in lengths of 18 to 20 feet. Doubling plates are worked at the bow for about 20 feet in length, and covering a space of 2 feet above and 2 feet below the load water line. Solid liners of thickness equal to that of adjacent plates are fitted between frames and outside strakes of plating.

The main deck planking is of yellow pine in lengths of 25 or 30 feet and 2½ inches thick. The butts are underlaid with 8-pound plates. Forecastle deck planks and top of deck house are of white pine 2½ inches wide and 2 inches thick, except in wake of the 3-pounder gun, where it will be thickened. The berth deck planks are of white pine 2 inches thick.

The deck house has a base plate 11 inches deep and 12½ pounds thick, an upper coaming plate 10 inches deep and 8½ pounds thick, and intermediate vertical 7½-pound plating. Vertical angle bars spaced 2 feet apart measure 3 by 2 inches by 4 pounds, and carry angle beams 3 by 2½ inches by 4½ pounds, with a spring of 7½ inches in 30 feet. The tops are 7 feet above tops of main deck beams at side.

The pilot house and chart room are given a clear height under beams of 6 feet 6 inches. Coaming plates of 8½ pounds are fitted at top and bottom, with 5-pound vertical plates between. The vertical stiffeners are frames consisting of 2½ by 2 inches by 3.7-pound angles about 2 feet apart, and carrying angle beams 2½ by 2 inches by 4.5 pounds. The roof is of white pine 1½ inches thick, covered with tar felt and No. 2 canvas. The bridge is constructed by extending the roofing of the chart room out on each side, the ends being supported by angle iron stanchions.

The rudder frame is of wrought iron, the minimum diameter of head being 4¼ inches. The pintle measures 2¼ inches in net diameter, with a brass sleeve ¼ inch thick. The frame is filled in with white pine and covered with 7½-pound plate. Chock pieces are fitted to limit the angle of turning to 40 degrees on

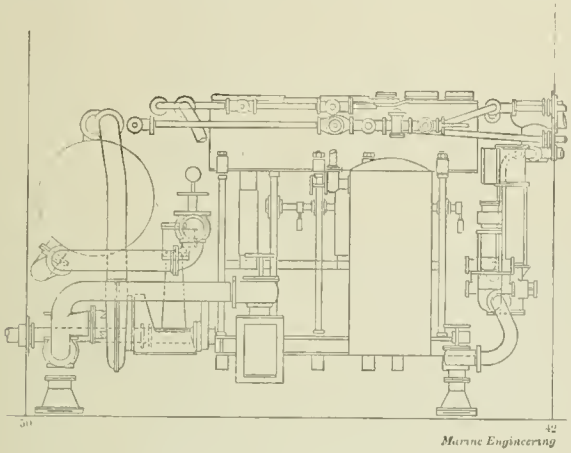


LONGITUDINAL SECTION AND PLAN OF MACHINERY LAYOUT.

each side of the center line. A quadrant on the rudder stock is connected with the steam steering engine by wire ropes and chains, appropriate connections to the steering wheel in the pilot house being made. Arrangements are made for steering from the pilot house, the bridge and the aft end of the main deck. The steering engine has two steam cylinders each 3½ inches in diameter by 3½ inches stroke.

THE EQUIPMENT.

Four boats are carried, being a 25-foot power launch, a 24-foot sailing launch, a 22-foot cutter and an 18-foot dingey. All are



INBOARD SIDE OF PORT ENGINE.

of hammered wrought iron, and rest in cradles. A single mast is fitted, measuring 64 feet over all, with a maximum diameter of 15 inches; it has a rake of 2 degrees.

There are two bower anchors of 800 pounds each, and two smaller anchors weighing respectively 200 and 110 pounds. The former are of the stockless type, and each is equipped with 75 fathoms of one-inch stud link chain. The anchors are handled by a davit about 4½ inches in diameter.

Six water tanks are fitted, two in the aft end of the fore hold having a capacity of 1,200 gallons; the two aft of the engine room bulkhead, 2,000 gallons; and two under the coal bunkers, 5,000 gallons. In each case the shell plating forms the bottom of these tanks, the other plating being 10 pounds thick.

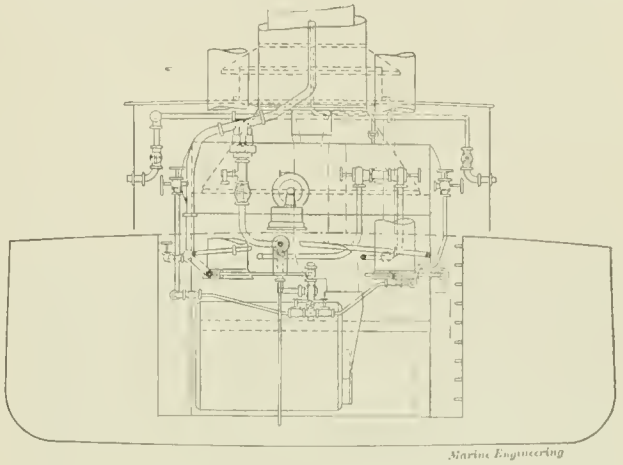
THE MACHINERY.

The main engines, which operate twin screws of 5 feet diameter, are of the vertical direct-acting triple expansion type, with cylinders 8, 13¼ and 22 inches in diameter, and a stroke of 18 inches. The indicated horsepower at 220 revolutions per minute will be about 600, the steam pressure being 200 pounds per square inch. The high pressure cylinders will be fitted forward and the low pressure aft.

The framing of each engine will consist of ten finished wrought steel columns, 2⅜ inches in diameter, efficiently stayed with tie rods. The bedplates are of cast iron.

The cylinder barrels have a thickness of ⅞ inch. Clearances at the ends of the stroke are ¼ inch at the top and ⅜ inch at the bottom. Each cylinder is fitted with a spring relief valve 1½ inches in diameter, loaded to gauge pressures of 225, 100 and 40 pounds respectively. Pistons are of cast steel with wrought steel followers, each being fitted with two packing rings of hard cast iron, held out by steel springs. The piston rods have a diameter of 2⅛ inches. Crossheads are of forged steel, with pins 2¾ inches in diameter, and 2¾ inches long on each side; slippers are of manganese bronze, with forward and backward sliding surfaces of 8 by 6½ inches. Connecting rods measure 42 inches between centers, and are turned to a diameter of 2 inches at crosshead end and 2⅞ inches at crank end.

Piston valves are fitted throughout, there being one for each high- and intermediate-pressure cylinder, and two for each low-pressure cylinder. The diameters are respectively 4¾, 6¾ and 7¼ inches, the thickness of working liners being ½ inch. The valves are single ported and of cast iron, finished all over. The valve gear is of the Stephenson type, with double bar links, and is so adjusted that the main cut-off under full gear at both ends of each cylinder will be about 72 percent of the stroke. The valve stems have a diameter of 1½ inches at the stuffing boxes, and 1⅛ inches where they pass through the valves. The eccentrics are made in two parts, and have an eccentricity of 1⅜ inches with a face of 2⅛ inches. Eccentric straps are of composition

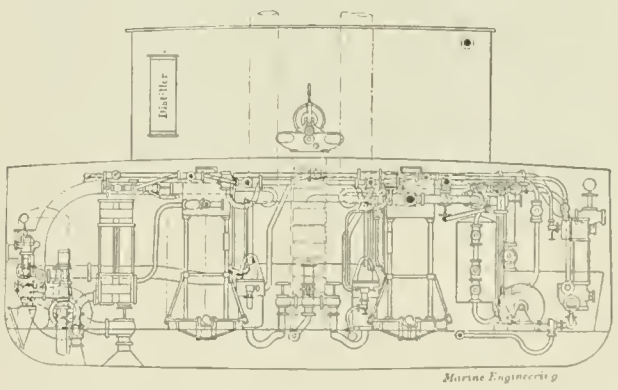


SECTION IN WAY OF BOILER ROOM.

lined with white metal. The eccentric rods measure 3 feet 4 inches from center of eccentric to center of link pin.

The cranks are set at an angle of 120 degrees, the throw being 9 inches. Crank pins are 6½ inches long with a diameter of 5 inches; crank webs, 6¼ inches wide and 3 inches thick, with ends chamfered. Each crank pin has an axial hole 2 inches in diameter. The crank shafts are solid, and in one piece, and measure 5 inches in diameter. Coupling disks are 1½ inches thick and 10½ inches in diameter.

The thrust shafts measure 4½ to 4⅞ inches in diameter, and about 12 feet in length. There are five thrust collars 1¼ inches wide and 10 inches in diameter, 1⅞ inches apart. The inter-



SECTION ACROSS ENGINE ROOM.

mediate shafts are 4½ inches in diameter and 11 feet 6 inches long, the aft coupling consisting of a sleeve 8 inches in diameter and 20½ inches long, bored with a double taper to fit intermediate and propeller shafts. The latter have a diameter of 4¾ inches and a length of about 26 feet.

The propellers will be manganese bronze, cast in one piece, the starboard propeller being right handed and the port left handed. Each will be held on the shafts by a composition nut covered by a watertight cap.

Each crank shaft will have six bearings, the forward three of which have a length of 5½ inches each, and the others 6 inches. The thrust bearings consist of cast iron pedestals

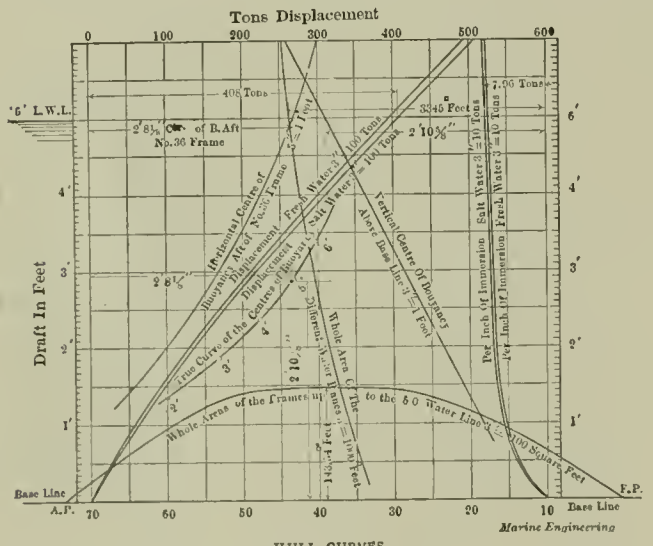
bolted to the foundation plates. Spring bearings are fitted for each thrust shaft. Stern tube bearings consist of a composition bushing made in halves, and fitted with sections of lignum vitae.

The reversing gear for each engine consists of a steam cylinder 4½ by 9 inches, with cast iron slide valve, and permits of an adjustment of the cut-off from 50 to 72 percent of the stroke. Turning gear is fitted for operation by hand.

AUXILIARY MACHINERY.

The one main condenser, which is independent, is fitted athwartship, aft of the engines, and has a cooling surface of 840 square feet. The shell is cylindrical, 5 feet 10¼ inches long and 3 feet inside diameter. It is made of steel ⅜ inch thick. The distance between tube sheets is 6 feet. The latter are of tobin bronze, ⅞ inch thick, stayed with ¾-inch rods of the same material. There are 858 seamless drawn composition tubes 6 feet 1¾ inches long, with an outside diameter of ⅝ inch and a thickness of No. 16 B. W. G. They are spaced 1⅛ inch between centers.

The list of pumps includes two main air pumps 13 by 7 inches worked from low pressure crosshead, with a 4-inch suction pipe from the condenser and a 3½-inch discharge pipe leading to main feed tank and overboard; one main circulating centrifugal pump



HULL CURVES.

with a 24-inch runner, and with two 7-inch suction pipes from sea and bilge respectively and a 7-inch discharge pipe leading to condenser and overboard; two main feed pumps 1¾ by 7 inches, worked from low pressure crosshead, with a 2-inch suction pipe from feed tank and a 2-inch discharge pipe to main feed; one main feed pump 7½ by 5 by 8 inches, duplex and independent, with a 2½-inch suction pipe from feed tank and a 2½-inch discharge pipe into main feed; one auxiliary feed pump 7½ by 5 by 10 inches, duplex and independent, with four 2½-inch suction pipes from feed tank, bilges, condenser and hose connection, and a 5-inch suction pipe from sea, and with four 2½-inch discharge pipes to feed tanks, condenser, auxiliary feed main and overboard, and a 3-inch discharge pipe to fire main; two bilge pumps, 1¾ by 7 inches, worked from low-pressure crosshead, with a 2-inch suction pipe from engine room bilge and a 2½-inch discharge pipe overhoard; one distiller circulating pump, 8 by 5 by 10 inches, with a 3-inch suction pipe from sea and three 2½-inch discharge pipes to distiller, flushing system and fire main; one independent bilge pump, 4½ by 6 by 6 inches with a 2½-inch suction pipe from bilges and a 3-inch suction pipe from sea, and two 2½-inch discharge pipes, one to flushing system and the other overboard; an evaporator feed pump, and an air compressing pump 4½ by 5½ by 5 inches.

Piston rod and valve stem stuffing boxes will be made of composition and fitted with metallic packing, and will be provided with efficient means for lubrication. The stern tube stuffing box will be made in halves divided longitudinally, with a packing space 6 inches deep and 1 inch wide, and so fitted as to prevent rotation of the packing.

In each fireroom will be two 24-inch ventilators of No. 10 B. W. G. steel, fitted with cowls of the same thickness and 51 inches maximum diameter. Two engine room ventilators, 18 inches in diameter, will be of No. 12 B. W. G. steel, and extend about 8 feet into the engine room; the cowls, of the same material, will have a maximum diameter of 44 inches.

The one evaporator will have a capacity of 1,700 gallons of water per twenty-four hours. The one distiller will have a similar capacity. Steam radiators are fitted for heating, with about 30 square feet of radiating surface for each 1,000 cubic feet of the spaces to be heated.

In the engine room will be a feed water heater with about 75 square feet of heating surface and operated by auxiliary exhaust steam. The combined feed and filter tank will have a capacity of about 300 gallons, and will be made of wrought iron plates ¼ inch thick. It will have 50 pounds of zinc plate suspended from the braces in a wrought iron basket, to obviate pitting.

The main cylinders and valve chests will be covered with magnesia and lagged with Russia iron, the upper cylinder heads having false covers. The steam cylinders of all auxiliary engines will be likewise lagged. All steam and exhaust pipes and valves, separators, the feed water heaters, etc., will be covered with magnesia and canvas. The main condenser will be covered with hair felt and Russia iron, as will the evaporator. Boiler drums and other exposed parts will be covered with magnesia and galvanized iron. The magnesia covering will consist of 85 percent carbonate of magnesia and 15 percent asbestos fiber.

THE BOILERS.

The main boiler will be of the marine watertube type, in a watertight compartment, and will have a length of about 9 feet 3 inches, a width of 11 feet 9 inches and a height of 11 feet, measured over the casing. It will have a total grate surface of 75 square feet, a heating surface of about 3,105 square feet (ratio 41.4) and will be operated at a working pressure of 200 pounds per square inch. The length of grates will be 7 feet. Generating tubes will be straight. The steam and water drum will have a diameter of 42 inches.

An auxiliary boiler of the horizontal return fire-tube type designed for 200 pounds steam pressure will be 5 feet 4 inches in outside diameter and 7 feet 3 inches long. It will have one corrugated suspension furnace ½ inch thick, 30 inches inside diameter and 5 feet 10 inches long. There will be seventy-six steel tubes, No. 11 B. W. G., 2¼ inches outside diameter and 5 feet 4 inches long. The grate surface will be 12.5 square feet, heating surface 296 square feet, calorimeter area 1.75 square feet. The ratio of heating to grate surface will be 23.7, and of grate to calorimeter area 7.1 to 1.

The uptake and funnel will be of sufficient size to give at all points a clear area equal to at least one-seventh the grate area. The uptake will be of three thicknesses of steel plate with double spacing of two inches. The funnel, which will measure 48 feet in height above the base line, will consist of inner and outer casings 5 inches apart. The inner casing will be made of No. 7 U. S. S. G. plates in the lower half and No. 9 in the upper. The outer casing will be of No. 12 plates.

There will be one Sirocco fan blower driven by steam turbine, located in the boiler compartment. It is designed to run with a steam pressure of 100 to 120 pounds, and will be connected with ducts to the ashpits, and to the ventilating system of the vessel.

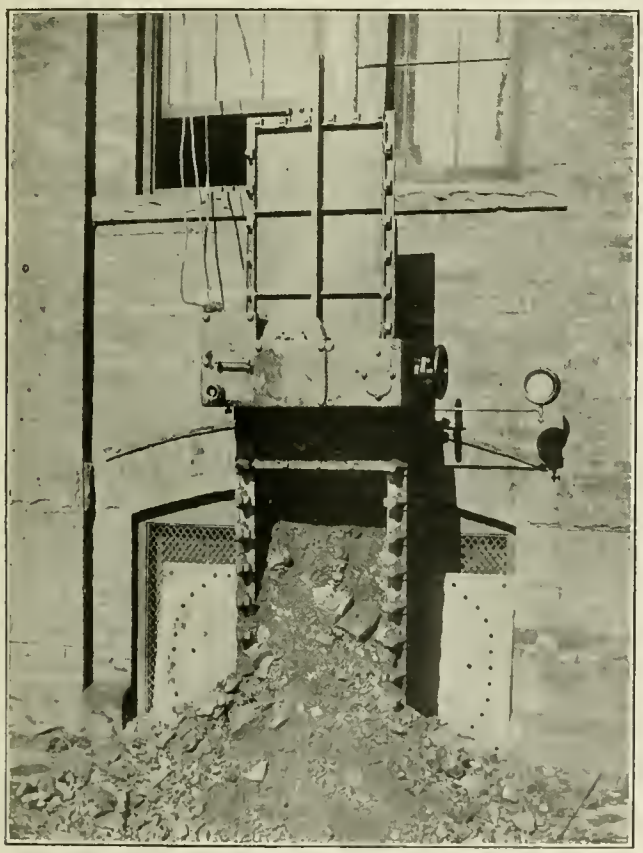
Main steam pipes will be of seamless drawn steel 3 inches in diameter, with 3-inch stop valves on the boiler. An auxiliary 3-inch steam pipe will connect from a stop valve on the boiler to a separator, from which two 2½-inch branches will be led.

Main exhaust pipes are of copper, 7 inches in diameter.

The main boiler will have a twin spring safety valve, with two valves 3 inches in diameter. The auxiliary boiler will have a single spring safety valve 2 inches in diameter. The springs will be of such a length as to allow the valves to lift one-eighth of their diameters, when they are set at 200 pounds pressure. They will have spherical bearings at the ends.

OFFICIAL TESTS OF ELECTRICALLY OPERATED BULKHEAD DOORS.

Ever since power operated bulkhead doors were introduced, there has been a good deal of speculation as to how these doors would work when called upon to cut through coal. How would they act under such conditions as prevail when the bunkers are full and coal of all sizes is distributed over the sill? In order to obtain information on these and other questions the United States Navy Department, through the Bureau of Construction



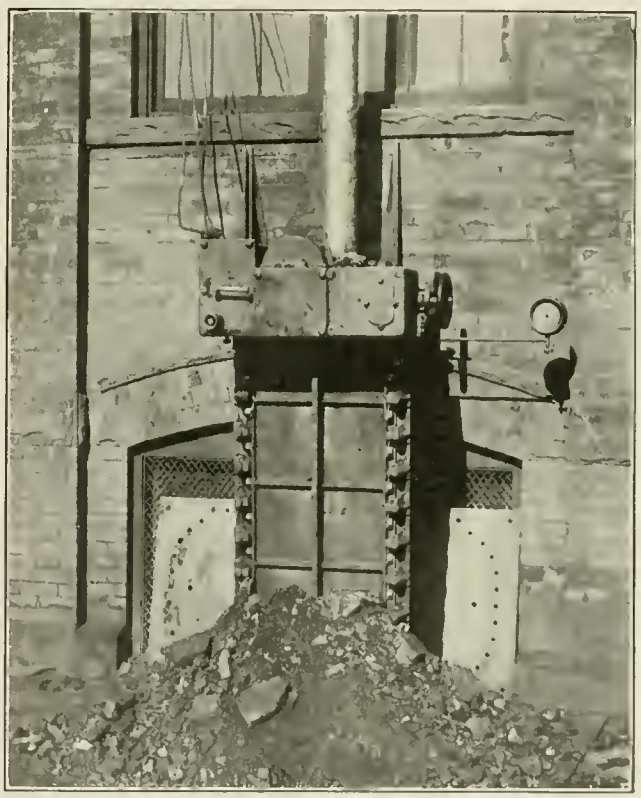
THE DOOR ABOUT TO CLOSE THROUGH COAL.

and Repair, has lately conducted unusually elaborate tests of the Long-Arm system power door, as installed on United States warships.

For the purpose of the tests were reproduced the conditions existing aboard ship when the coal bunkers are full and the doorways between the bunkers and the fireroom are open and choked with coal. The tests included also a reproduction of the situation which would arise in the event of a hull puncture admitting an inrush of water sufficient to sweep the coal through the doors.

Fanciful descriptions of "ponderous doors crashing through the coal" are responsible for much misconception as to the actual working of power doors under such conditions. As a matter of fact, no door has ever been built that would always cut through all the lumps of coal which might be in its path, and after that seat itself perfectly watertight. To be safe for the men working in the firerooms, a door operated from the bridge of the ship must close reasonably slowly, so that the men will have ample time to get out of its way. If the men fear the doors they will block them open, which condition completely foils the proper use of any power door. When a door operates at a safe speed, it can invariably be prevented from closing by a very large lump of coal, for it is practically impossible to bring sufficient force to bear upon the door plate to cut through everything that may come in its path. In some types of doors, their whole object has been defeated by the fact that the guides and tightening wedges are so constructed that they become clogged with fine coal dust, and the door in closing often becomes tightly wedged on this compressed dust and stops in a partly opened position. No power could close the door under these circumstances.

For the doors under test, there has been evolved, during an experience with hydraulic, pneumatic and electric power doors covering eight years, the most satisfactory design of guides and



DOOR CLOSED INTO COAL BY EMERGENCY SYSTEM.

tighteners to prevent fouling by coal dust, and the most suitable thrust upon the door plate to secure efficient closure and the greatest safety to the ship. In these and other respects the Model C door now being manufactured is an evolution, for almost every valuable feature is the result of long continued sea service, coupled with the experience and close study of experts in this particular specialty. The official trials here described show that this type of door is equally suitable for coal bunker and passage openings.

GREAT ENDURANCE SHOWN.

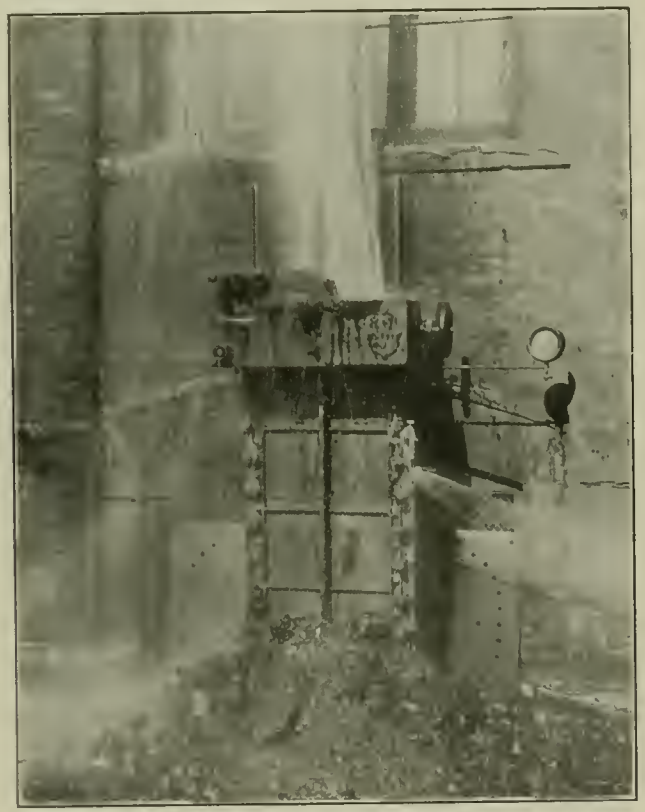
Before proceeding with the coal and water tests the door was operated continuously for a period of several days, during which time it was opened and closed over 3,000 round trips. The Bureau of Construction and Repair considered this test equivalent to ten years of actual service on a warship. During this severe trial all that was necessary to keep the door in perfect operative condition was to oil several of the bearings once a day; that is.

about once for each 700 round trips. The controller received no attention whatever, and the contact fingers were found in excellent condition at the end of the test; the motor also received no attention during the entire test. The worm and the worm-wheel, by which power is immediately applied to the door, were lubricated before the test started and not at all during the test; they were found in excellent condition at its completion.

The durability of the door is even more impressively demonstrated by the fact that immediately before making the trials for the Bureau, a duplicate of the prescribed tests was carried out by the company to make sure that everything would run properly. The result was that the particular door in question passed through a series of openings and closings equivalent to twenty years' actual service upon a warship, without showing appreciable wear.

CONDITIONS OF THE TEST.

In carrying out the tests the power door was secured to a steel box, which was intended to represent a coal bunker, and



LEAKAGE UNDER 35-FOOT HEAD, AFTER EMERGENCY CLOSURE.

connected by a large pipe with an immense tank upon the third floor of the building where the tests were conducted. At the lower end of this pipe was located a valve for controlling the flow of water; and also a gauge for measuring the pressure in the box, which could, if desired, be continuously maintained at 15.2 pounds per square inch, equivalent to a 35-foot head of water above the sill of the door.

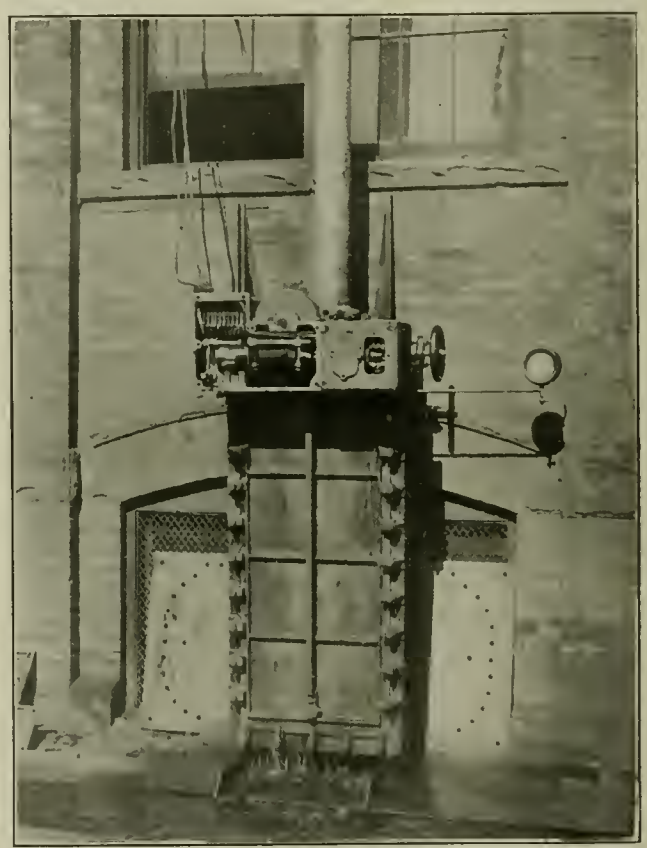
The box upon which the door was mounted was filled with coal, which was allowed to run out through the door opening in the same way that it would if the door were opened from a coal bunker. Large lumps of coal were mixed with the layer of all sizes. Before closing the door upon this mass of coal, fine coal dust was shoveled and thrown up all over the tighteners and the frame, in order that the conditions of the test might be as severe as possible. To make the coal dust stick in sufficient quantity, the bulkhead frame and tighteners were covered with thin oil.

The door was then closed from the bridge emergency station; the door plate cut through nearly all the coal, and the clear opening was practically completely closed when the automatic cut-out opened the circuit and stopped the motor.

In order to make this closure through coal possible it is essential that the door plate should work freely in sliding up and down, and not be forced against the bulkhead frame until it reaches nearly its completely closed position. At this stage the door plate was forced away from the bulkhead frame by the pressure of the coal, and the clearing space between the door plate and bulkhead frame was largely filled with fine coal dust.

SMALL LEAKAGE.

After the door had closed into the coal by the electric emergency action, and been stopped by the automatic cut-out, the water from the tank above was let into the box back of the door plate, and a head of thirty-five feet above the sill was maintained by adjustment of the valve. A thin film of spray



LEAKAGE UNDER 35-FOOT HEAD, COAL CLEARED AWAY.

worked its way through the clearance space between the bulkhead frame and door plate, and in some places the water succeeded in washing out the fine coal dust which had collected. At this time the actual leakage measured less than 75 gallons per minute. The water back of the door plate soon worked its way down through the coal to the slight opening at the bottom, and washed away the pile of coal in front, thus relieving the resistance to the thrust of the door plate, causing the automatic cut-out to throw in the current again, and allowing the door to complete its closure.

The escape of water, such as it was, would occur only on a coal-bunker door which could not completely close owing to fine coal collected upon the frame, and if the door plate did not ride freely in its ways and the clearances already referred to were not allowed, the plate would probably have stuck fast when only partly closed, and it would have been impossible to complete the closure except by opening the door and wiping it clean. It has been found by experiment that this clearance of

the door plate in its ways is an absolute necessity, in order to enable coal-bunker doors to come to a full close.

During another test the door was clean, as would be the case on a passage door, and the leakage under this condition is remarkably small. While this small leakage of a door closed in coal may seem undesirable, it is certain that any other type of door, if subjected to the same tests which the door under trial was put through, would fail to close the clear opening at all, while with the Long-Arm door the opening was safely closed (owing to the action of the automatic cut-out before and after the coal was washed away) and the leakage could be readily taken care of by the usual pumps.

PERFECT PROTECTION OF THE MOTOR.

It was clearly shown by the tests described that one of the reasons why this door works so perfectly on a coal bunker is because the motor is protected by an automatic cut-out which opens the circuit as soon as the load upon the motor becomes greater than it can safely handle, and when the load decreases to a safe amount the circuit is automatically closed again by the same device.

It is usual to protect motors with fuses in the incoming circuits, but these tests show that such means would not be suitable for a power door, for the reason that if it should strike an insuperable obstruction, such as hard packed dust or a large lump of coal in closing, and the fuse should be blown, the door would be absolutely inoperative (except by the hand gear) until some one could replace the fuse. The automatic cut-out is to the motor what the safety valve is to a boiler, except that instead of weighing the internal pressure of the boiler and giving relief when it exceeds a proper limit this cut-out automatically weighs the thrust exerted by the door plate, so that when this exceeds a predetermined limit the circuit is opened.

It was shown by the tests that the cut-out gives to the door an almost human intelligence in its action when operated from the emergency station. For instance, when the door closed into a mass of coal and struck a lump so large that it could not cut through it, the circuit to the motor was opened; but nevertheless the device was not inoperative, for when water got into the bunker back of the coal, it at once loosened the mass of coal beneath the door plate. As soon as this was done the pressure upon the plate was relieved, the circuit again closed, the motor again started and complete closure of the door was effected, as if the work had not been interrupted.

The principle upon which the automatic cut-out is based, and its mechanical construction are really very simple. The motor is directly connected to the worm engaging the wormwheel already referred to, which, in turn, transmits the load through its shaft and a pinion to a pin rack upon the door plate. In performing its work, the worm exerts a thrust in the direction of its axis, and this thrust is borne by a specially constructed bearing supported by a heavy helical spring. This spring has upon it an initial load equal to the greatest thrust which it is desired that the motor shall deliver. As soon as the thrust actually exerted by the worm exceeds the initial compression upon the spring the latter gives way slightly, allowing the wormshaft to move axially. This motion of the wormshaft is used to interrupt the circuit, and the same motion in the reverse direction (when the excess load is removed) will complete the circuit which it has previously broken.

The Bureau of Navigation reports that there were constructed in the United States during the month of February, 54 vessels of a total of 21,586 gross tons. Of these, 7, of 16,200 tons, were steam vessels constructed of steel. Two of the total were of over 6,700 tons each, and were constructed on the Great Lakes. The remaining 52 ships had an aggregate of 7,906 tons, or an average of 152.

MODERN PRACTICE FOR FIRING WATER TUBE BOILERS IN LARGE VESSELS.

BY H. C. DINGER, U. S. N.

The usual method of firing Scotch boilers with natural draft, using 12 to 15 pounds of coal per square foot of grate, was to allow each fireman to regulate his own fires. Fires were carried somewhat higher in front than in back, green coal was put on the front and the gases allowed to distil and pass over the live coals at back, the coal gradually being worked back. Fires were raked and sliced at intervals and cleaned in rotation.

With large water tube boilers, where the furnaces are wide and it is necessary to burn as much as 50 pounds of coal per square foot of grate per hour, this older method of firing does not answer the purpose with satisfactory results.

When such large amounts of coal per square foot of grate are to be burnt it is naturally necessary that every part of the grate be brought into use for actual combustion, and for this reason the clear, live fire must extend over the entire grate. In order to avoid holes in some parts of the fire and the accumulation of thick masses of green coal in others it is necessary to carry the fire level over the whole grate. Holes in the fire allow an extra amount of cold air to be admitted above the fire. This cold air cools the gases and causes smoke. In order to enable a proper amount of air to penetrate the layer of fuel so as to completely burn it, the fires must be carried thin, that is, six or seven inches thick. If not carried thin the air will fail to come in contact with a large part of the coal, and combustion is checked and incomplete, resulting in the formation of smoke, unburnt gases and carbon monoxide.

The great losses in firing are—

(1) The unconsumed coal which drops through the grate and falls into the ash pan, extra losses being caused by excessive slicing;

(2) Unconsumed fuel which passes up the stack in the form of smoke;

(3) Formation of carbon monoxide, CO, instead of carbon dioxide, CO_2, due to lack of sufficient air at various points of the fire. When coal is completely burned to CO_2, 14,500 heat units per pound of carbon are obtained; when CO is formed only 4,400 heat units are extracted.

To overcome the first of these losses, slicing must be avoided as far as possible, and in practice it can be avoided much more than is usually supposed. Slicing is done to break up the clinker and to allow the air to get at the mass of coal. If the formation of clinker is avoided the necessity for slicing is decreased. With light fires clinker will form much less readily than with heavy fires. A tendency to clinker can also be checked by breaking up and raking the fire with a leveling hoe from above.

Smoke, one of the results of incomplete combustion, is caused by an insufficient local supply of air, and by a cooling of the gases before combustion is completed. The latter condition can be avoided in part by not opening furnace doors while there is green coal on the fires. An extra supply of air at points where there is likely to be a deficiency can be obtained by admitting air on top of the fire. This is usually done through either the furnace door or the dead plate. The system of admitting air through the dead plate is preferable since in this way the air as supplied is first heated before reaching the fuel.

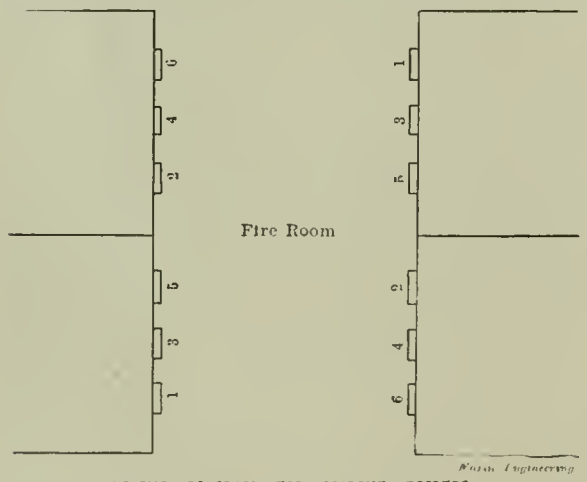
A lack of proper air supply at local points of the fire is also caused by having thick or uneven fires. The air is unable to penetrate the thick masses of green coal and hence does not come into proper contact with these portions of the fuel, which then give off large quantities of smoke on account of the gases being distilled but not burnt. To avoid this fires must be carried evenly all over the grate; they must be carried light; they must be fired

lightly and often, and in regular rotation. Large lumps of coal must not be put into the furnaces.

In general, to arrive at proper conditions of firing it will be necessary to observe the following:

1. Carry an even fire all over the grate, not over seven inches thick even with two or three inches air pressure.
2. Fire the whole grate evenly so that each part may get the same supply of coal.
3. Keep the fire continually level.
4. Avoid throwing in lumps larger than a man's fist.
5. Fire only small amounts of coal at any one time, so as to avoid a thick mass of green coal at any point or for any period of time.
6. Fire quickly and keep furnace doors open as little as possible.
7. Scatter coal thoroughly when it is put on, so that a layer of green coal can not be formed at any point of the fire.

The formation of carbon monoxide is caused by lack of sufficient air at portions of the fire. A proper supply of air above the fire will enable the CO to take up the other atom of oxygen in the combustion chamber or above the back of fire if the furnace is large enough at that point. With furnaces having a combustion chamber or a high furnace at back it is possible to have the combustion completed before the gases strike the tubes. Sometimes the complete combustion takes place in the uptake or smoke stack, and is called secondary combustion or flaming



FIRING DIAGRAM FOR MARINE BOILERS.

at funnel. This secondary combustion causes a very high temperature in the stack. It can be readily seen that the formation of CO is much more likely with heavy thick fires or uneven fires, and can be avoided by carrying clean, even and light fires.

SYSTEM OF FIRING.

In order that all the firemen may readily keep a uniform fire, and that the same amount of coal may be consumed in each furnace, a regular system of firing must be established and controlled by a central authority. A system for doing this will now be described.

On the large armored cruisers and battleships in the navy the boilers in any fireroom are arranged to face each other, there being either four, five, or six furnaces on each side. The furnaces are given numbers as in the diagram.

This arrangement is adopted so that when the furnace doors are fired in rotation according to the numbers, no two fires in any one boiler or half of a boiler are fired one immediately after the other. The men do not interfere with each other, since the fires to be fired at the same time are widely separated, and the firemen alternate with each other in firing and taking a spell of rest, the numbers being arranged with these special ends in view. A fireman is assigned to each three adjoining fires or to two adjoining fires, which are leveled a short time before being fired. For leveling and breaking the fire up from above a light long-handled hoe is used.

In starting to fire on this system No. 1 furnace is fired first; immediately after this No. 3 is leveled. Then at an interval, about one minute, No. 2 is fired and No. 4 leveled. Another interval, and No. 3 is fired and No. 5 is leveled. Then No. 4 is fired and No. 6 is leveled; No. 5 fired and No. 1 leveled, and so on in regular rotation.

No more than five shovelfuls are allowed to be thrown into the furnace at one firing and in every case only sufficient to keep the fire at its proper height is put on. The coal must also be scattered evenly all over the fire.

By carrying out this system fires are leveled about two minutes before coal is thrown on. This allows a good surface to be formed for the reception of the green coal. The leveling prevents the formation of hills and holes in the fire and checks the formation of clinker. Leveling must be understood to mean an actual leveling of the whole fire and breaking up of clinker by the use of the hoe from above, but does not mean the shoving back of the coal against the bridge wall.

Firemen are warned not to use the slice bar unless it is absolutely necessary to break up the clinker. Slicing is done during the firing intervals whenever necessary.

In order to have a means for maintaining an accurate firing interval, timing devices of various kinds are used. These devices usually consist of a light and a number, or a gong and a number, lighted or rung at regular time intervals, so as to indicate the time for firing the furnace whose number is shown. Among these are Kilroy's stoking device, largely used in the British navy, and one used in the Italian navy. A home-made device of this character is described by Lieutenant Lackey in the September, 1905, *Proceedings of the United States Naval Institute.*

The specifications for such firing device for the new vessels of the United States Navy are as follows:

There will be in each fireroom an electrical device for regulating the intervals of firing the furnaces. They will be adjustable to give any desired interval between firing. The device will consist of a cylindrical case with a dial perforated with openings equal in number to the number of the furnaces in its fireroom; each opening will be covered with an opaque glass having a number on it left clear, each number corresponding to a furnace.

Behind the glazed opening there will be electric lights which will be switched on and off successively by an electric motor located in the after fireroom. This motor will run continuously, and will be so arranged that all lights on the same side of the ship having same number will be illuminated at the same instant, to be followed by the lights of the same number on the other side, and so on till all the furnace numbers have been illuminated.

There will be a gong in each fireroom to call attention to the number displayed.

SMOKE PREVENTION.

The prevention of smoke in water tube boilers is mainly a question of proper firing. By carrying the fires light and even, firing light and often and avoiding the dumping of thick layers of green coal on the fires, supplying air above the fire and keeping furnace doors closed except when necessary for throwing on coal, smoke can be greatly diminished and almost avoided.

It is however a most difficult task to make firemen, especially those used to Scotch boiler practice, keep their fires in the non-smoking condition, but the increased economy and reduction in actual labor of handling the coal will amply repay any extra trouble necessary to establish the improved system.

Japanese Naval Additions.

The Japanese are felicitating themselves upon the launching on December 26 of the large armored cruiser *Tsukuba,* which has a displacement of 14,000 tons. This is the first armored

cruiser built in Japan, and by a considerable margin the largest ship ever built in that country. She is to be an extremely powerful vessel, the armament as at present understood consisting of four 10-inch and twelve 8-inch guns. It is just possible, however, that two 12-inch guns may be substituted for the four 10-inch, in which case she would have the same battery as the *Vittorio Emanuele,* the famous design of Col. Cuniberti. The speed is not known, but as she comes under the head of an armored cruiser, it will probably be not less than 22 knots.

In this connection it might be mentioned that the Japanese are engaged in a very extended program for additions to their navy, the ships including two large battleships recently launched in England; one battleship of 18,000 tons, to be laid down at the dockyard at Yokosuka, and another at Kure; the *Tsukuba,* which was laid down in February, 1905; the *Ikoma,* laid down in December, 1904; the *Ibuki,* to be laid down at Kure, and the *Kurama* at Yokosuka. The last four ships are armored cruisers of the same size.

The Battleship Rhode Island in Commission.

On February 19 the new first class battleship *Rhode Island,* constructed by the Fore River Shipbuilding Company of Quincy, Mass., was placed in commission at the Boston Navy Yard. The *Rhode Island* was authorized by act of congress June 7, 1900; contract for her construction was signed February 15, 1901; the keel was laid May 1, 1902, and the ship was launched May 17, 1904. The contract price for hull and machinery was $3,405,000.

The *Rhode Island* is the first to go into commission of five battleships carrying superposed turrets, these being the only battleships with this arrangement at present under construction, and, with the exception of the *Kentucky* and *Kearsarge,* the only such ones which have ever been built. The length is 435 feet on the water line (441 feet 3 inches over all); the beam is 76 feet 2½ inches, and the displacement on mean draft of 23 feet 9 inches is 14,948 tons. This includes normal coal supply of 900 tons. With the full supply of 1,700 tons, and with a complete equipment of stores and ammunition, the ship will displace 16,094 tons. The added displacement per inch of immersion at normal draft is 60.95 tons, giving a draft with full load of 25 feet 4 inches.

The ship is propelled by twin screw engines, designed to develop 19,000 horsepower and give her a speed of 19 knots. This latter was slightly exceeded on trial. The engines are of the four cylinder, triple expansion type, with cylinders 35, 57, and 66 and 66 inches in diameter, and a common stroke of 48 inches. Steam is supplied by twelve Babcock & Wilcox boilers with an aggregate of 1,342 square feet of grate surface and 56,184 square feet of heating surface, the ratio being 41.8 to 1.

The ship has an extremely powerful battery, exceptionally well arranged. It includes four 12-inch and eight 8-inch rifles; twelve 6-inch rapid fire guns; twelve 3-inch; twelve 3-pounders; eight 1-pounders; eight machine and two field guns; with four submerged 21-inch torpedo tubes. The arrangement of the battery is such that the broadside includes four 12-inch and six 8-inch guns, while fore-and-aft fire includes two 12-inch and six 8-inch guns.

The armor belt amidships has a thickness at the top of 11 inches, tapering to 8 inches at the bottom. Barbettes for the 12-inch guns have a thickness of 10 inches on the exposed sides and 7½ inches in the rear; those for the 8-inch guns are respectively 6 and 4 inches in thickness. Turrets for the 12-inch guns have front plates of 12 inches and rear plates of 8 inches in thickness, while the 8-inch guns have turrets 6½ and 6 inches thick. The protective deck amidships has a thickness of 1½ inches on the flat, 3 inches on the slopes, with a 3-inch thickness forward and aft. The complement of officers and men numbers 812.

THE UNITED STATES BATTLESHIP RHODE ISLAND, COMMISSIONED FEBRUARY 19, 1906.

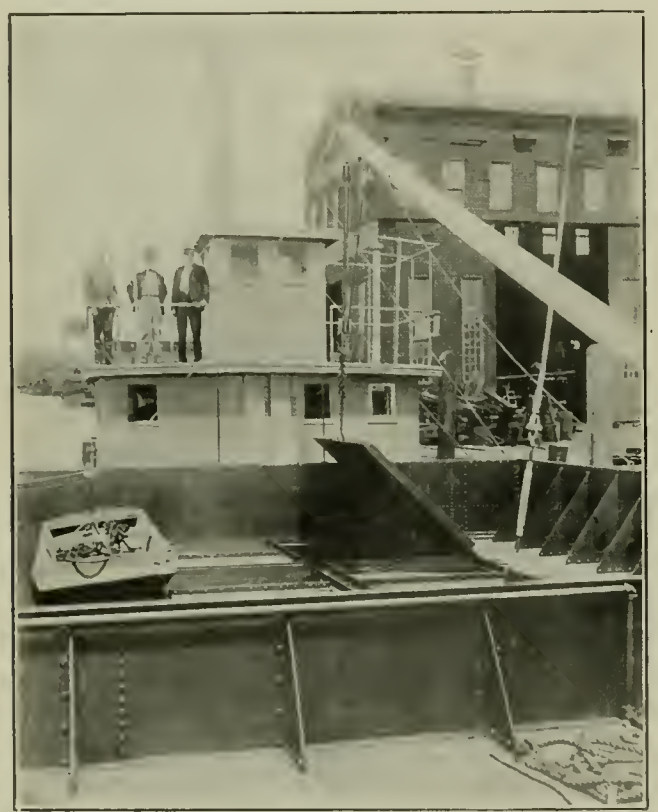
Ship owners will be interested in the repeal on February 22 of the act permitting the registration or enrollment under certain limitations of a foreign vessel wrecked in United States waters. As the law now stands, no such vessel can be placed under the American flag except by special act of congress.

A SELF PROPELLING ASH, COAL AND WATER BARGE.

"United States Navy water barge No. 14," which recently left the yards of its builders, the Pusey & Jones Company, Wilmington, Delaware, to enter upon its service at the United States coaling station, Guantanamo, Cuba, has embodied in its construction some novel features. This boat has been designed to carry both coal and fresh water to vessels in the harbor, and to take from them ashes, which can then be dumped overboard where the accumulation will not tend to obstruct navigation.

The general dimensions are: Length over all, 80 feet; beam, 30 feet; depth, molded at hopper, 7 feet; depth, molded at ends, 8 feet 9 inches; length of hopper, 35 feet.

The barge is of heavy construction and draws 2 feet 9 inches in running condition ready for cargo, with a capacity on a draft of 5 feet of 124 gross tons. The space available for the various kinds of cargo is about as follows: Ashes, 7,500 cubic feet; coal,



DECK VIEW OF BARGE NO. 14.

5,000 cubic feet (119 gross tons); fresh water, 3,600 cubic feet (100 gross tons); salt water ballast, 1,660 cubic feet (47.5 gross tons). Accommodations are also provided for miscellaneous cargo in the fore hold. The cuts show the locations of the various compartments.

Coal can be loaded and unloaded by means of the cargo boom or in any way desired. This boom is of one ton capacity, and is operated by a hoisting engine. It is also used to lift the doors which form the bottom of the coal bunker when the boat is to be used for carrying ashes.

A four-inch plug in the deck amidships port and starboard admits water to the fresh water tanks, and valve opening to the sea below the waterline admits salt water to the ballast tank.

The eight dumping hole doors are operated as shown, four from the engine room and four from the forward hold. Each set can be raised by one man as if it were but one large door. The doors are released by a blow on a pawl and the ashes drop into the sea.

A large duplex pump is furnished to pump fresh water from the tanks to vessels, to pump the salt water overboard, to wash out the ashes and clean up generally, and to drain the forward and after bilges. Check valves on the fresh water tanks keep the salt water out of them. After the pump has been used for salt water, a few strokes of fresh water pumped overboard will clean out whatever salt remains in it, and the short distance of piping common to both systems, and no salt water will get into the tanks to which the barge is supplying water. Water may be taken from either or both of the fresh water compartments, or from either or both of the salt water compartments, at one time. The deck plugs for hose connection are on either side of the house aft, and hose is supplied both for the supplying of fresh water to vessels and for washing decks.

The house aft contains two cabins with two berths apiece, and a galley fitted out complete. The outfit in general includes boat davits and an anchor davit, two 680-pound anchors and 120 fathoms of $\frac{1}{8}$-inch chain, and mooring bitts and cleats, as shown.

THE BARGE AFTER BEING LAUNCHED.

The barge is propelled by two 50-horsepower compound surface condensing engines, steam for which is supplied by a Scotch boiler, 6 feet 8 inches diameter and 9 feet 8 inches long, at 150 pounds working pressure. The engines are widely separated, but their operating levers are brought close together near the center line. A different tone of bell for each engine enables the engineer to operate them independently in any way desird. It will be noticed that the boiler is placed athwartship, balanced by the location of the coal bunker, fresh water tank and most of the auxiliaries to port.

A trial trip on the Delaware river proved the boat to be in every way satisfactory. It was towed out through the tortuous channel from the works of the builders to the open river, and after proving that with both screws going ahead it could turn in a small radius, and with one going ahead and the other astern turn completely around while in practically the same place throughout several revolutions, it navigated its own way back to the wharf. The trial with and against the tide over the measured mile course showed an average speed 6.7 miles per hour with 130 tons displacement, and 5.7 miles with 233 tons displacement.

H. H. T., Jr.

The New Battleships.

Editor. Marine Engineering:

Twelve months have passed since the navy bill of last year became a law, and all that time has been consumed by bureau chiefs in drafting plans and destroying them.

Differences of opinion among these heads, regarding the amount of space and weight to be alloted to each vessel for boilers, engines, coal bunkers and other features are responsible for this condition of affairs. This controversy has aroused a decided feeling of hostility in congress against the navy—or

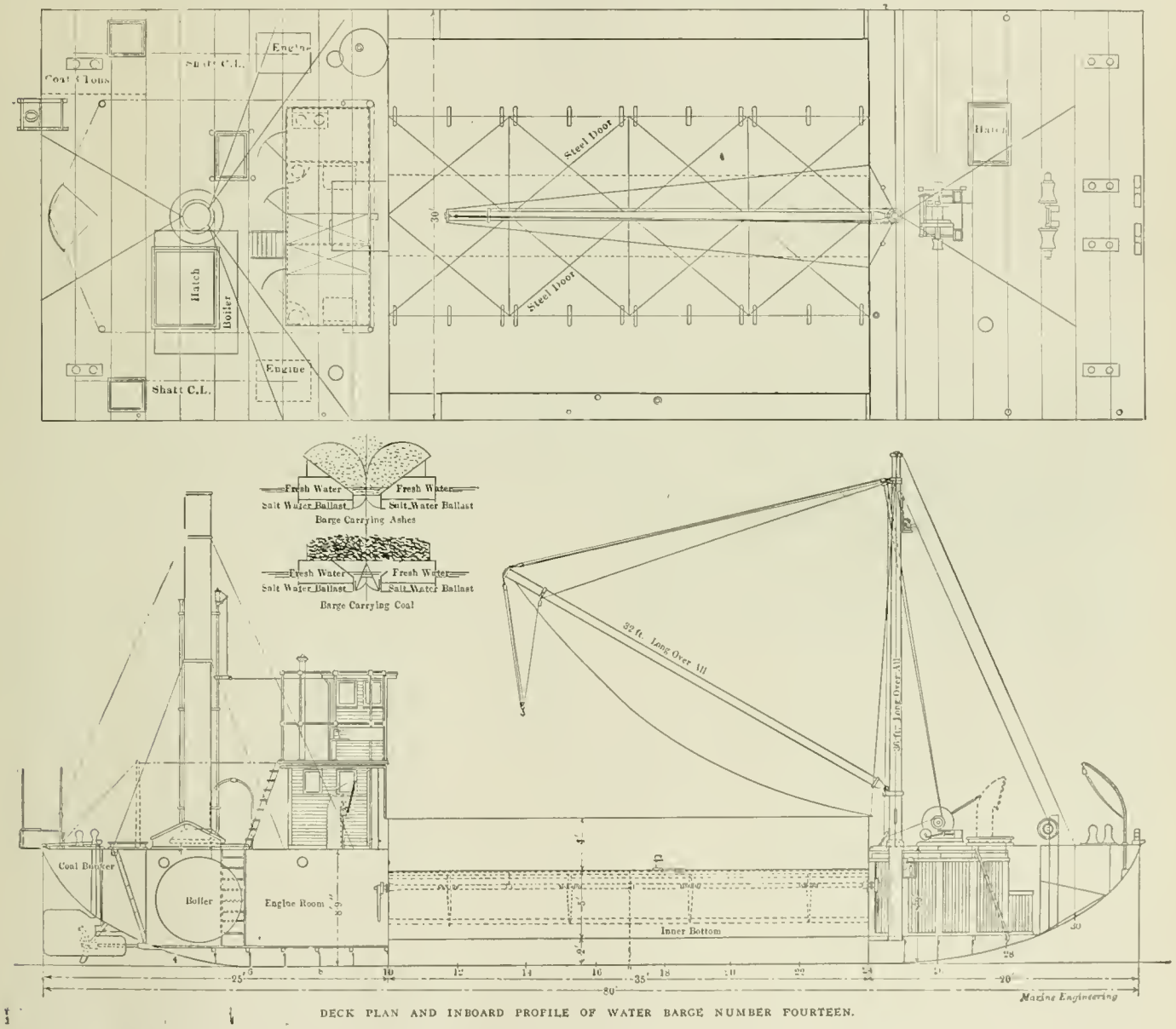
rather, the navy department—and it is practically certain that nothing will be done this year in the way of authorizing new warships. One additional battleship would have been provided for, in all probability, thus following out the recommendation of the President, but for the extraordinary indecision among the bureau chiefs since last March.

Chief Constructor Capps informed the naval committee recently that "tentative plans" were still being prepared, and that he believed that by July 1, 1906, the department would be ready to authorize the beginning of construction. One member of the committee is quoted as saying: "It will be useless for the naval committee to ask the House to appropriate money for another battleship, with absolutely nothing done toward building the two vessels authorized last March. We are trying to keep the facts about these two vessels quiet, so that we will not be embarrassed on the floor by being called upon to defend the inaction of the department."

Since the reorganization of the Bureau of Construction and Repair, just after the retirement of Admiral Hichborn, this bureau has undergone drastic changes created by the new school of naval constructors, who are now in complete charge. The civilians (commonly known as draftsmen) who served under the former bureau chiefs, have been disrated and detached from the bureau and their places filled by technical graduates of little or no practical experience. Among those whose services were dispensed with were the two leading draftsmen, who are mainly responsible for fine specimens of American warships such as the *Olympia, Oregon, Kearsarge, Wisconsin, Ohio, Pennsylvania,* the torpedo boat destroyers, and in fact practically all the vessels in our new navy. When these men requested the reason for such treatment, they were told it was due to "simply a change in methods."

It is unjust that men who have devoted their lives to the shipbuilding industry are tossed about by a corps of young naval officers, many of whom have had little or no experience in practical shipbuilding and designing. Such is the condition of affairs in the Bureau of Construction and Repair at the present time, and yet congress is amazed at the length of time for executing the plans for the two battleships appropriated for one year ago. Under the administrations of the former chief constructors (who were, by the way, appointed from civil life) no such conditions prevailed as are at present brought to our notice. Possibly we might say they were not hampered by such a thorough technical training. As all the shipyards are hungry for work, let us have the battleship plans at the very earliest date possible.

X-Ray.



DECK PLAN AND INBOARD PROFILE OF WATER BARGE NUMBER FOURTEEN.

THE SUCTION PRODUCER-GAS YACHT EMIL CAPITAINE.

BY LEON RAMAKERS.

The gas engine, in conjunction with a suction gas producer, if properly designed, is the most economical generator of power (apart, of course, from natural sources), which the world has known. The hourly consumption of fuel with such a plant is as low as one pound of anthracite per brake horsepower. A good compound-condensing steam engine uses from two to five pounds per brake horsepower per hour, according to size and type. With the oil engine the consumption is approximately one pint (= one pound) of gasoline per brake horsepower per hour. Anthracite costs about $4.60 per ton, and gasoline about $30 for the same quantity. It will therefore be seen that the respective costs for fuel are:

For the oil engine 6.5
For the average good steam engine..... 3.5
For the producer-gas plant ..... 1.

Then, again, with the growing use of the spirit and the oil motor for small powers, it seems to be evident that in the course of time the world will not produce sufficient oil to keep pace with the demand; or, at least, the price of this fuel will so increase as to make the use of the engine employing it no longer sufficiently

THE YACHT EMIL CAPITAINE.

remunerative. The advantages, however, of the internal combustion motor for many purposes, and particularly for certain classes of marine work, are so obvious that it is desirable to retain it. These considerations lead us to see the great future there is for the suction gas-producer plant for marine work, provided it can be satisfactorily adapted to the conditions of service afloat.

A paper was recently read before the Institute of Naval Architects, by Mr. Thornycroft, upon the subject of gas motors, and shortly following this it was found that the principle had been very thoroughly thought out by Herr Emil Capitaine. Messrs. Thornycroft became intimately interested in the work which he was doing in this connection. As it appeared that his was an eminently practical and satisfactory system, Messrs. Thornycroft entered into an agreement with him to take over the sole British rights in his suction gas-producer plant (Messrs. William Beardmore & Company, Ltd., sharing with them the rights to manufacture the larger types), and they are now manufacturing this in certain sizes suitable for marine work.

In this connection it is interesting to note that the first recorded instance of a vessel being propelled by an internal combustion motor was the auxiliary yacht *Djezirèly*, belonging to the Marquis d'Nare d'Aubais, which, in the early "sixties," was fitted with a Lenoir engine. It is curious to note that this engine was of a heavy type, and used gas as its fuel, but in this case the gas was generated on shore and stored under pressure in cylinders or tanks aboard the vessel.

The introduction of the explosion motor using oil or spirit as fuel followed, and it is only in recent years that the importance of the self-contained gas-producer plant has been realized.

Herr Emil Capitaine has fitted several vessels with his gas engines and producers, with which he has achieved some quite remarkable results in sheltered waters on the continent, but the yacht which Messrs. Thornycroft have built and engined with plant constructed by them on the Capitaine system, and which they have entered for the Motor Yacht Club's reliability trials, is the first vessel of its kind to run in the open sea. This yacht, which out of compliment to the inventor of this system of propulsion has been christened *Emil Capitaine*, is built as a sea-going small motor yacht, and is fitted with permanent cabin accommodation.

The hull is of galvanized steel plate, and has a length of 60 feet, with a beam of 10 feet, and is designed on the Thornycroft principle, which has been adopted in many of their boats, whereby a broad flat stern is obtained, and the propeller works in a tunnel. This ensures great steadiness without causing the stern to settle down unduly when running in the water, and further a clear and unobstructed flow of water is maintained to the propeller. The yacht is provided with two saloons, one forward and one aft, both of which are handsomely lined throughout with polished teak. Lavatory conveniences are arranged off the after saloon. The boat is intended primarily as a day boat, but there would be no difficulty in arranging bunks in the forward saloon for sleeping accommodation. A neat hand winch is fitted right forward for manipulating the cable. In the after part of the boat is provided a steel-lined well, with automatic draining valves, suitable for carrying luggage or a motor car if desired.

The power for propulsion is derived from a suction producer-gas plant in conjunction with a specially-designed gas engine. These have been built by Messrs. Thornycroft from designs and on the principle invented by Herr Capitaine. The engine is of the vertical inclosed type, having four cylinders each 8¼ inches in diameter by 11 inches stroke, and running at 300 revolutions per minute it gives about 75 horsepower on the brake.

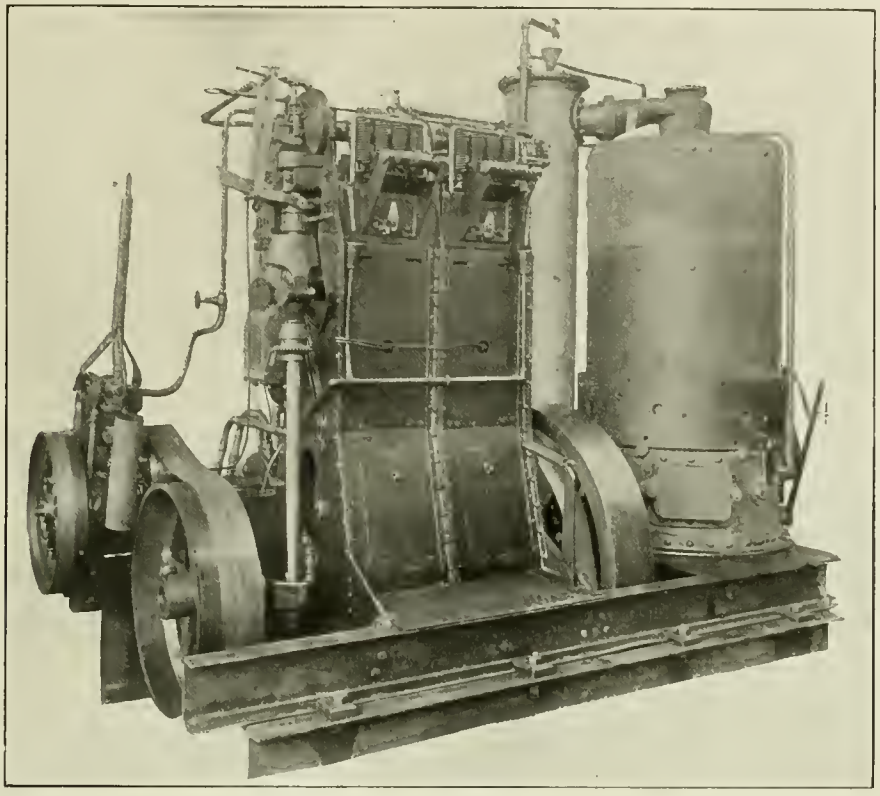
The inlet and exhaust valves are all mechanically operated, the cam shaft being placed above the top of the cylinders and slightly out of the center line, and the valves actuated by means of rocking levers. The cam shaft is hollow and carries in it a sliding shaft, which by means of radial arms projecting through slots in the cam shaft, operates the low-tension ignition strikers. The longitudinal motion of this inside shaft, which is controlled by the governor of the engine, varies the time of ignition, advancing it as the speed of the engine increases. Arrangement is provided whereby the timing of the magneto machine is simultaneously varied to correspond with the point of ignition. The engine itself is controlled by means of a throttle valve in the induction pipe connected by a special arrangement to the governor. There is besides provision for completely cutting out the electrical circuit when the speed of the engine exceeds a certain limit.

Half-compression gear is provided for starting the engine, which is done by a separate 6-horsepower Thornycroft motor through the medium of a belt. The half-compression cams are automatically thrown out of action by means of an attachment to the governor, when the engine is running at normal speed. A centrifugal pump, driven from the engine, is provided for supplying cooling water to the combustion heads and cylinder jackets. The exhaust is also water-jacketed, and the gases are discharged up a funnel, no muffler being required. A reciprocating pump of special design is provided for forcing oil in turn to all bearings.

Special provision is made to facilitate the cleaning of the cylinders, valves, etc., and a peculiar feature of the engine is that although the combustion heads are separate from the cylinder barrels yet the explosive strain on the combustion heads is taken not by the connecting bolts but by the whole framework of the engine. Doors are fitted in the lower part of the engine casing to provide access to bearings, etc. At the forward end of the crank shaft is

a pulley for driving a gas dryer, and a centrifugal pump for pumping the heated and dirty water from the gas purifier.

The gas producer is of the ordinary cylindrical shape. It is lined with fire brick and has three charging doors in the top, which deliver into a conical annular hopper. A fire grate and air



THE PRODUCER PLANT AND ENGINE.

and steam inlets are provided in the lower part, as usual. A special feature of the gas-producing plant is the arrangement for drying and purifying the gas without using any solid material in the scrubber, as is usual. The hopper of the producer carries enough anthracite for a ten hour's run at a speed of about 10 to 12 miles an hour.

The total floor space occupied by the engine and producer is 12 feet 6 inches by 9 feet 4 inches, and the height in each case is 6 feet 8 inches.

Editor's Note: We are informed by Emil Capitaine & Company, 25 Whitehall street, New York, who are looking after the American interests of the Capitaine gas engine and producer, that the coal consumed for a 10 horsepower engine amounts to about 1.1 pounds per indicated horsepower per hour. This figure is stated to be decreased with increasing powers of the engine, becoming 1 pound at 30 horsepower and about 7/8 pound at 50 horsepower. Of course these figures cannot be directly compared with those for a steam plant, because of the fact that the quality of coal used is necessarily more expensive. But even taking account of this fact, there seems to be a very decided economy in the coal bill.

An engine of 25 horsepower is said to occupy floor space of 32 by 75 inches and a height of 50 inches. For double this power the height is the same and the floor space is 32 by 103 inches, the weight for the larger engine being only about 25 percent greater than for the smaller size. These engines are built invariably in multiple cylinder form, the standard sizes at present being 25 horsepower 2 cylinder; 75, 150 and 300 horsepower 3 cylinder; 50, 100, 200 and 400 horsepower 4 cylinder.

An interesting test was made in November, 1904, between a tug fitted with this type of generator and engine and a steam-propelled tug of about the same size and power. The maximum pull recorded by a towing meter reached 2,190 pounds for the producer tug and 2,020 pounds for the other. On a ten hours' run at 8½ knots the producer tug consumed 530 pounds of anthracite, and the steam tug 1,820 pounds of steam coal.

Progress of Naval Vessels.

The Bureau of Construction and Repair, Navy Department, report under date of March 10, 1906, the following percentage of completion of vessels building for the United States Navy:

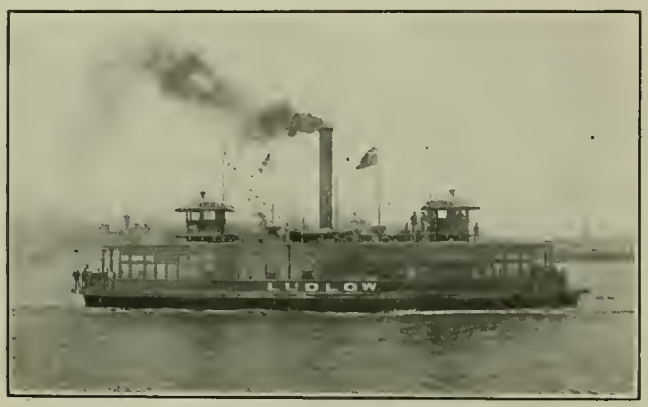
				Feb. 1.	Mar. 1.
BATTLESHIPS.					
Virginia	19	knots.	Newport News Co.	98.6	99.
Nebraska	19	"	Moran Brothers Co.	86 17	90.
Georgia	19	"	Bath Iron Works	93.35	94.59
New Jersey	19	"	Fore River Shipbuilding Co.	96.5	97.5
Connecticut	18	"	Navy Yard, New York, N. Y.	95.16	96.13
Louisiana	18	"	Newport News Co.	95.24	97.19
Vermont	18	"	Fore River Shipbuilding Co.	73.5	76.3
Kansas	18	"	New York Shipbuilding Co.	72.5	74 2
Minnesota	18	"	Newport News Co.	82.08	83 52
Mississippi	17	"	Wm. Cramp & Sons	49.08	51.21
Idaho	17	"	Wm. Cramp & Sons	47.19	49.18
New Hampshire	18	"	New York Shipbuilding Co.	37 1	39.3
ARMORED CRUISERS.					
California	22	knots.	Union Iron Works	88.7	90.
South Dakota	22	"	Union Iron Works	87.3	89.1
Tennessee	22	"	Wm. Cramp & Sons	94.53	94.53
Washington	22	"	New York Shipbuilding Co.	94.4	95.5
North Carolina	22	"	Newport News Co.	34.48	37.04
Montana	22	"	Newport News Co.	30.11	32.41
SEMI-ARMORED CRUISERS.					
St. Louis	22	knots.	Neafie & Levy C[illegible]	.34	90.56
Milwaukee	22	"	Union Iron Work[illegible]	.	90 9
SCOUT CRUISERS.					
Chester	24	knots.	Bath Iron Works	18.87	22.28
Birmingham	24	"	Fore River Shipbuilding Co.	21.	24.5
Salem	24	"	Fore River Shipbuilding Co	21.1	24.9
SUBMARINE TORPEDO BOATS.					
Submarine No. 9			Fore River Shipbuilding Co.	51.	61.
" " 10			Fore River Shipbuilding Co.	43 3	48.9
" " 11			Fore River Shipbuilding Co	43 5	50.9
" " 12			Fore River Shipbuilding Co	43.1	48.3

Electric Plant on the Ferryboat Ludlow.

BY FRANK C. PERKINS.

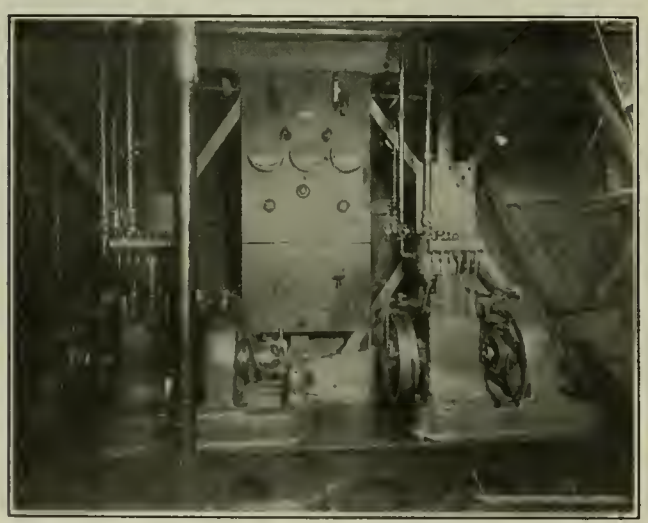
The accompanying illustrations show the electric installation on the *Ludlow,* which is in ferry service between St. Johns and Carleton, New Brunswick, as installed by Frank T. Vaughan, of the former city.

The engine room is equipped with two sets of engines and dynamos, constructed by the Canadian General Electric Company. Each of these units consists of a small engine directly coupled to an electrical generator of 4-K.W. capacity, at 110 volts pressure, and a speed of 600 revolutions per minute. The engines have cylinders 4½ inches in diameter with a 4-inch stroke, and are of the vertical high speed type, operating at a pressure of 80



THE FERRYBOAT LUDLOW.

pounds per square inch. These engines are said to be automatically governed, so that a variation in load of 25 percent will affect the speed of the engine no more than 2 percent. Each engine and dynamo is mounted on a single bed plate with a



ELECTRIC PLANT OF LUDLOW.

rigid connection between the shafts. The generators are used exclusively for incandescent lighting of the ferryboat, and are of the direct current, constant potential type, with compound winding. These multipolar machines are self-regulating, and fitted with automatic oiling devices, with oil reservoirs fitted with sight glasses. The efficiency of the electrical machines at normal load is said to be 80.5 percent, which is good for the small size of the machines. It is stated that they can operate for an indefinite period without heating either the bearings, armature or field coils, or commutators more than 70 degrees above the surrounding air, and can stand an overload of 25 percent for one hour without excessive heating. They are so compounded that the voltage will not exceed 115 or fall below 110 volts, between full load and no load.

The ash pits are constructed of 10½-pound plate and 2½ by 2½ inch by 5-pound angles, supported by angle stanchions from the floors; they are 5 inches deep and have one inch of cement coating on the bottom.

The feed pump is of the horizontal, simplex type with a steam cylinder 4½ inches in diameter and a water cylinder 2¾ inches in diameter, the stroke being 6 inches. This pump, and the fire pump, the air pump and the sanitary pump, were constructed by the George F. Blake Manufacturing Company. The fire pump has two 7½-inch steam cylinders and two 5-inch water cylinders, while the air pump is a 4 by 8 by 6 Blake vertical simplex featherweight pump, having composition air ends, with steam cylinder lagged with Russia iron and polished brass bands.

The lighting equipment of the *Ludlow* includes 112 lamps of 16 candle power, operating at 110 volts pressure. These lamps have an efficiency of 3.1 watts per candle power, and it is guaranteed that the candle power will not decrease more than 20 percent after burning 600 hours. The switchboard shown in the accompanying illustration is mounted between the two engines, and is made up of two panels of slate 1¼ inches thick, having two positive and one negative buss bars, together with the usual automatic circuit breakers, ammeters, voltmeters and controlling switches.

The New English Scout Cruiser Adventure.

The *Adventure*, the most recent English destroyer of destroyers, has lately completed her official trials, which were very satisfactory. The main dimensions of the vessel herewith illustrated are: Length, 374 feet; beam, 38 feet 3 inches; molded depth, 23 feet 3 inches; draught, 12 feet 6 inches; displacement, 2,620 tons; coefficient of fineness, 0.51. The main engines, which in this class of vessel have to be heavier than is usual in destroyers, are of the Marshall-Allen patent six-cylinder type, designed for 16,000 horsepower at 250 revolutions. The aim of the design is, by adopting small cylinders with comparatively short strokes, to decrease weight and height, to decrease strains due to moving weights, and to give equable torque, all without increasing the piston speed.

The twelve boilers of the *Adventure* are of the latest Yarrow type, in which all the incoming feed is caused to traverse the outer rows of tubes before mixing with the evaporating water. Experience has proved the advantage of this arrangement. The total grate area is 784 square feet; heating surface, 42,686 square feet; ratio, 54.4 to 1; the two rows of tubes on either side nearest the fire are slightly curved; their diameter is 1⅜ inches, that of the remainder, 1⅛ inches. There are three fire rooms, with four funnels; each fire room has two vertical double-breasted fans, driven by vertical closed engines with forced lubrication. Area for air inlet, about one-seventh of grate area; full speed periphery velocity of fans, about 97 knots. The brickwork of the boiler is fitted independent of the boiler casing, and air is admitted through a number of the hottest bricks above the fuel. Wing passages are provided to the boiler rooms, enabling better supervision and speedy attendance of the officer on watch when necessary; a system which is clearly preferable to that of climbing along over the hot tops of the boilers and diving at intervals.

The bunker capacity is 450 tons, the vessel doing ten nautical miles per ton of coal at 10 knots. The storage space is divided into upper and lower bunkers, there being eight of the former on each side, giving excellent protection to both boilers and engines, and three of the latter abreast the fire rooms, thus twenty-two bunkers in all.

Each engine has one surface condenser having tubes 10 feet long, with double flow of circulating water, which enters at the

after ends of the lower tubes. The cooling surface in each condenser is 6,800 square feet. The main engines have ample rubbing surfaces, there being eight long and two short bearings for each crank shaft. The connecting rods have their pins shrunk in and secured. The high-pressure rods have no soft packing; the remainder have the closed type with soft packing outside. These glands worked well, the records showing that the loss of water from all wastes was only 7.6 tons on the eight hours' full speed trial, this being largely due to the safety valves lifting. The loss from all sources, including safety valves, syrens, gauge cocks, leaks and drains, was less than one-third the amount permitted by the Admiralty rule for loss of water, which is one gallon per horsepower per day. Each boiler has an automatic feed regulator. The auxiliary feed pumps are capable of feeding for full power, and were tested to prove this for three hours during the full-speed trial.

The means for adjustment of main bearings and connecting rods is very efficient. Graduations on the fixed parts are marked, and the nuts can be turned and locked so as to give each adjustment 1-144 inch of tightening or slackening of brass. It is impossible for the nuts to slacken, having first to shear two cotters. The arrangement is snug, and obviates the sometimes experienced accident in which the greaser, fond of wearing finger rings, has found a small split pin seize his ring, and so cut his finger to the bone.

The highest speed obtained during the trials was 25.955 knots, and there were indications that 26 knots could be maintained. The other results were: Number of revolutions per minute, 251.6; indicated horsepower, 15,850. E. O.

THE ENGLISH SCOUT CRUISER ADVENTURE ON TRIAL TRIP.

British Naval Scouts.

Great interest has been taken in the production of the new class of scouts recently ordered by the British Admiralty. H. M. S. *Forward*, the first of two built by the Fairfield Shipbuilding Company, Glasgow, has completed her official steam trials. She realized, as a result of six runs over the measured mile at Skelmorlie, on the Clyde, a mean speed of 25.286 knots when developing 14,995 indicated horsepower. The guarantee on contract was a speed of 25 knots. The increase is a quarter of a mile in excess of the guarantee, with 1,500 horsepower less than that stipulated. This proves that the form of the hull is exceptionally satisfactory, and that the machinery is of high efficiency.

The *Forward*, and her sister ship, the *Foresight*, belong to a new class in the British navy, the first two of eight ordered and intended for scouting duty. Speed is the dominant consideration, and a radius of action at 11 knots of 5,000 miles has been realized. These vessels have only ten 12-pounder and eight 6-pounder guns, with two tubes on deck for firing 18-inch Whitehead torpedoes, to enable them to deal with torpedo-boat destroyers. Their principal function is to bring news, and therefore speed is the first object. Their length between perpendiculars is 365 feet, beam 38 feet 9 inches, and they displace 2,850 tons on a draft of 14 feet 2 inches, with 150 tons of coal in the bunkers, sufficient to carry them 1,500 nautical miles at 10 knots. There is bunker capacity for 500 tons of coal, to give a radius of action of 5,000 nautical miles at the same speed. The speed of 25 knots involves a high rate of combustion in 12 boilers of the modified Thornycroft type, but on the official full-power trial the air pressure in the stoke-hold was under 2 inches. The boilers working under easy conditions supplied adequate steam for the engines, which are of the four-cylinder, triple-compound type, driving twin screws.

A 96-hour coal consumption trial at the most economical speed was made. On four successive days the vessel returned to the measured mile at Skelmorlie to ascertain the speed for the mean revolutions made by the engines during each 24 hours. At the end of this 96 hours' trial it was found that the power for 10.66 knots was 829, and that the average rate of fuel consumption was 2.66 pounds per indicated horsepower per hour. Other trials were made at various speeds, which indicated that a 25-knot speed can be realized with a considerable margin of power. The *Forward*, loaded to her full draft, then had her full-speed tests. Two preliminary runs were made over the measured mile at 23 and 24 knots while working up speed, and the official eight-hour test commenced with six runs over the measured course. The engines were linked up a bit as there was no need for a full effort to meet the requirements. The first run over the mile, with the tide, was made in 2 minutes 20⅘ seconds, equal to a speed of 25.568 knots. On the return run the tide made a difference of 1⅘ seconds, while the third run, again with the tide, occupied ⅖ second more than the first run. The ship continued to and fro for six runs in all, the variation between the longest and shortest times being 2 seconds. Analysis of the runs showed that the mean speed of all six runs was 25.286 knots, the horsepower of the engines averaging as above 14,995 for a mean of 211 revolutions per minute.

After completing the six runs, the *Forward* continued on an eight-hours' course, the engines maintaining about the same number of revolutions. She headed down the estuary, and then steamed up Kilbrannan Sound, and finished the circumnavigation of Arran in a very short period. When the eight-hours' trial terminated, a variety of maneuvering tests were undertaken at full power, and the trials going astern with three-fourths of the engine power were interesting as indicating possibilities of the cruiser escaping from tight corners. The summation of the results taken each hour showed that the revolutions averaged 210 per minute, and that the mean horsepower was 15,022. The air pressure in the stoke-hold was 1.8 inches; the average steam pressure at the boilers 250 pounds, and at the engines 230 pounds. The vacuum was 25 inches over the whole eight hours, and the speed was quite 25¼ knots, though the ship had not been in dock for two months previous to the trial. Benj. Taylor.

MOTOR BOATS, X.

BY DR. WILLIAM F. DURAND.

PRACTICAL BOAT CONSTRUCTION.

Within the limits of the present series of articles it will be quite impracticable to undertake any comprehensive discussion of the art of boat building. Brief consideration may, however, be given to the general principles which underlie the work of the boat builder, and to the general methods whereby those principles are carried into practical effect.

The fundamental purposes of the boat builder are two in number:

(1) The realization of the desired form.

(2) The provision of the necessary strength.

The principles and practice of boat building, therefore, circle about these two things, *form* and *strength*. The first has reference

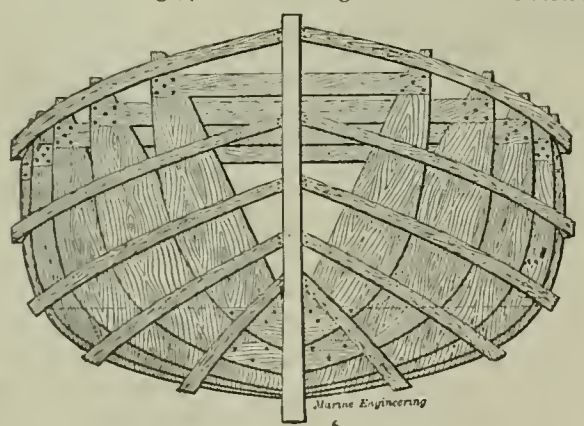


FIG. 48. BOAT SET UP WITH MOLDS.

to geometry and the second to mechanics. Many other secondary purposes must, of course, receive due attention; such as those having relation to matters of convenience or comfort, and dependent primarily on personal taste. These are, however, of only collateral importance or interest, and we may therefore confine our attention to the principles which are involved in the attainment of the two main purposes— the realization of form and the provision of strength.

The first point to be made clear is that while the main purposes are thus stated under two heads, it by no means follows that two sets of structural members are to be provided, one set having special reference to form and the other to strength. Quite on the contrary, the skill of the boat builder is largely expended in devising ways and means for attaining most effectively both purposes by the same set of structural members, or in any event in avoiding as far as possible the use of members which relate to one of these purposes alone. The boat builder's ideal in such matters is naturally a structure in which both the determination of form and the provision of strength shall be provided by substantially the same sets of structural members.

Turning now to the question of form, it is clear that the actual form of the surface of the boat will be determined by the outer skin or planking. But planking alone cannot be assembled in the proper form without something over which it may be bent or formed as desired; and even when so bent the planks would scarcely retain permanently their form without an internal

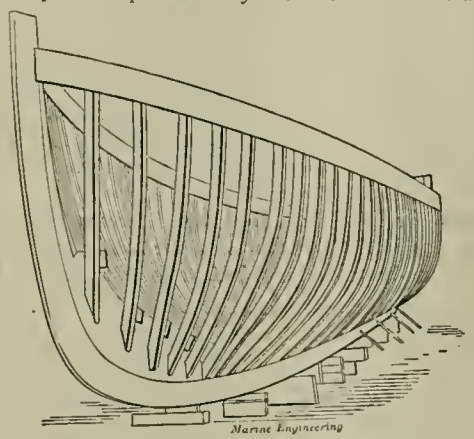


FIG. 49. BOAT IN FRAME, READY FOR PLANKING.

framework or stiffening which shall be permanent in form by itself, or rather which with the planking shall make a combination permanent in form under the conditions of service intended. The fundamental feature in the realization of form is therefore the planking. In fact the planking is in a sense the essence of the boat—all else is auxiliary or secondary—and to realize the planking two things are necessary:

(1) Frames or forms of some kind over which the planking may be bent and secured in shape.

(2) Some permanent internal stiffening or frame work which shall serve to assist the planking in maintaining the form given to it.

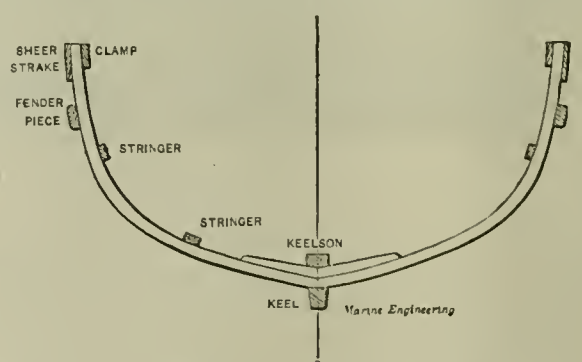


FIG. 50. MIDSHIP SECTION, SHOWING LONGITUDINALS.

At this point we find two different practical methods of boat construction. In one which is quite commonly employed in building canoes, rowboats and quite small motor boats and launches, the forms over which the planking is bent are simply wooden molds put in place temporarily, their sole purpose being to bring the planking to the proper form for the outer surface of the boat. In the second type, which is always used for larger boats, the internal framework, consisting of frames and cross ties or deck beams, is formed and erected in place first, and the form of the boat is thus determined in skeleton. The planking is then bent over the frames and secured to them, and is thus brought to the form desired. In this case, therefore, the forms over which the planking is bent constitute a permanent part of the structure. Fig. 48 shows a boat set up with molds and the form thus determined, and illustrates the distinctive step in this mode of construction. Fig. 49, on the other hand,

shows a boat in frame, with the form determined in skeleton, and thus illustrates the distinctive feature of the other mode of construction.

We must now turn to a consideration of strength, which we may conveniently examine under three heads:

(1) Longitudinal strength.
(2) Transverse strength.
(3) Local strength.

By longitudinal strength we mean the capacity to resist bending of the boat as a whole, or any general distortion in the fore and aft lines.

By transverse strength we mean the capacity to resist such distortion as would produce a change of form in the transverse sections, or in their relation to each other, as by a gradual twist about a fore and aft axis.

By local strength we mean the capacity to resist local stresses of such a character as may tend to pierce or tear the hull at some particular point, but which may not necessarily tend to produce any general distortion or change of form in the boat as a whole.

With reference to longitudinal strength, the boat must he treated as a beam or girder, and must contain longitudinal members so disposed as to give the needed strength and stiffness in this direction. To this end the planking naturally contributes very largely, and as a rule only certain supplementary members are required, chiefly near the top and bottom of the boat, considered as a girder. For such purposes some combination of keel, keelson, sheer strakes, deck and side stringers, clamps and fender pieces may be fitted. These various members are illustrated in Fig. 50. Only rarely would they all be fitted in one design. In Fig. 51 is also shown the arrangement adopted in a case of actual design, and illustrates good practice with reference to these details. In Figs. 52 and 53 are likewise shown sections of a boat of the extreme high speed type, the former about amidships showing the engine under a turtle back, and the latter aft near the rudder showing the stern nearly resting on the surface of the water. See also Figs. 33 and 35.

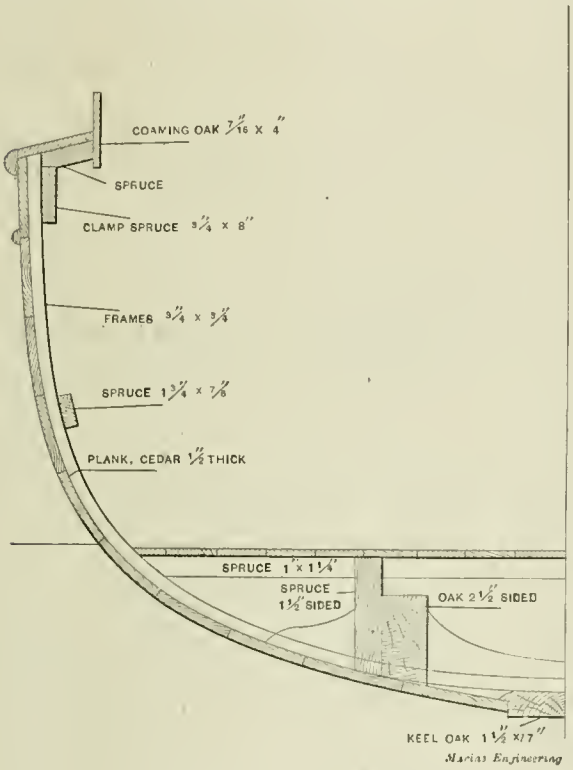

COAMING OAK 3/16" x 4"
SPRUCE
CLAMP SPRUCE 3/4" x 8"
FRAMES 3/4" x 3/4"
SPRUCE 1 3/4" x 7/8"
PLANK, CEDAR 1/2" THICK
SPRUCE 1" x 1 1/4"
SPRUCE 1 1/4" SIDED
OAK 2 1/2" SIDED
KEEL OAK 1 1/2" x 17"
Marine Engineering

FIG. 51. MIDSHIP SECTION OF 38-FOOT SPEED LAUNCH.

Turning now to the question of transverse strength, we find that the planking, together with the internal framing over which it is fitted, provide together the primary or chief item of strength in this direction. These parts in particular, therefore, represent the double use of structural members—for the determination of form and for the provision of strength. It is clear that the spring of the frame and that of the planking will naturally oppose each other, and that out of this equilibrium under opposite forces there will arise a degree of strength with regard to transverse distortion. The weak part of such a structure as illustrated by an absolutely empty shell made up of planking and frames will clearly be at or near the gunwale, where the equilibrium of planking and frames would be difficult to secure or to maintain,

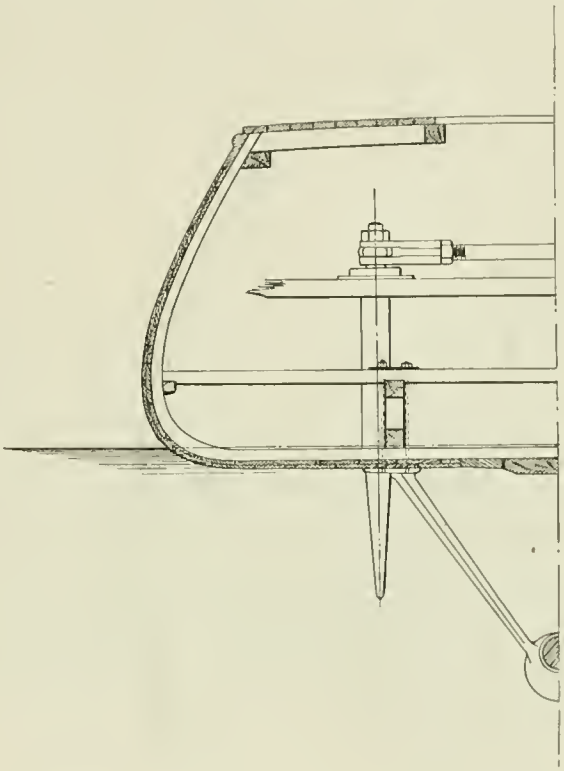


FIG. 52. SECTION OF VERITAS IN WAY OF RUDDER.

and in consequence of which the sides would tend either to open out or to collapse, thus in either case changing the effective beam of the boat. To remedy this defect, deck beams, serving either as struts or as ties, as may be needed, are fitted except in the way of cockpits or other deck openings. Here deck stringers as shown in Figs. 51 and 52 are fitted, thus supplying at these points the needed special strength against transverse distortion. The laying of the deck planking on the deck beams adds also its quota of transverse strength against compresssive stress, though the primary purpose of the planking must be put down as shelter or convenience rather than as transverse strength.

So far furthermore as the deck planking is continuous fore and aft, it adds an important item to the schedule of members furnishing longitudinal strength, and its possible function in this direction should therefore not be overlooked.

The function of the floor as an item of transverse strength should also be noted. The floor is a transverse vertical board or piece of thin planking, secured to the bottom of the frame and extending from side to side across the keel. In the way of cockpits the upper edges of a series of such floors are lined up so as to form the foundation for the bottom of the pit or opening The function of the floor is to tie across and consolidate the frames, skin planking and keel at the bottom of the boat, and thus

to give strength and stiffness along the keel with reference to transverse or twisting distortion, and to furnish an element of support at the keel, considered as a joint about which the two sides of the boat may tend to work when subjected to transverse forces.

Coming next to the question of local strength, it is naturally found to result that except at special points the needed local stiffness and strength may readily be provided by the members intended for general strength in the transverse and longitudinal directions. Hence for the construction in general no special provisions are required for local strength, and it is only at special points, such as about the stem and fore-foot along the side where contact with a dock may be likely, under the engine, about the propeller shaft supports, as in Fig. 53, etc., that structural members specially intended for local strength are introduced.

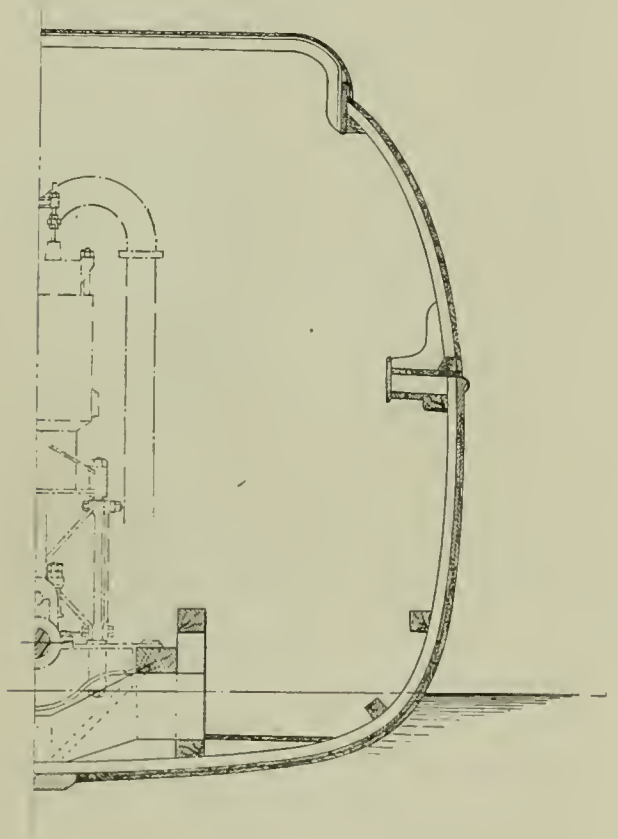


FIG. 53. SECTION OF VERITAS ABOUT AMIDSHIPS.

Local strength at the bow and at occasional other points in the framing is secured by filling in with chock, angle or knee pieces as shown by the cuts of longitudinal sections. Local strength along the side may be secured by a special fender or rubbing strip as shown in Fig. 50. Local strength under the engine is secured by a special foundation formed usually of longitudinal timbers or of structural steel which are intended to connect with the structure of the boat, and so lead away gradually into the structure of the boat as a whole the local stresses developed at the engine—see Fig. 51. A particular caution may be given here to avoid making such special foundation too short or too localized in character. It should be remembered that the real support of the engine is the boat, and that the object of the foundation is to give local strength and to bring to the support of the stresses developed, the maximum amount of actual boat structure.

(TO BE CONTINUED.)

A LITTLE STORY.

BY ADAM NED PHULE.

The manager of Ball & Ball sat before his roller top desk in a nice, comfortable, leather-back chair, reading his morning mail. Letter after letter was deposited in its proper basket for distribution, but one was laid aside and taken up when the distribution was finally made, and it read as follows:

Dear Sirs:—The somewhat delayed engines on your valued order, No. 167,283, are now ready for inspection and test. According to our contract, dated June 8, of last year, you agreed to have your inspector here at once on notification, and it is imperative that you comply with this part of the agreement to avoid further delay on account of penalties. Anticipating your prompt action, we are, Yours very truly, Henks & Henks Co.

The manager touched the bell.

"Mr. Mason, you just send Jenks, of the constructing department, to-day, without fail, to Henks & Henks to inspect the engines on our order No. 167,283."

"Send Jenks! Why he must go to ——."

"Now Mr. Mason my directions must be complied with. You will please make out an expense warrant at once, and I will sign it, and Jenks must get off before night."

"Well, if you say so he must go, but job No. 169,440 is most urgently needed."

"Yes, yes, I know that, but on his return he can take that up, or perhaps you can send Sawyer."

"He is at Berry's with no end of trouble on his hands."

Two days later Jenks was in the shops of Henks & Henks, and for several days he was hard at it, and the engines were started and ran nicely.

"Hello, Jenks! When did you get out here?" This was the greeting from Martin, the inspector of engines for the motive power department of Ball & Ball.

"Why, three days ago. When did you leave the office?"

"I got my expense warrant and was told to 'fly.' I am to inspect the engines for my department on job No. 167,283."

The following morning a letter from the manager to Jenks read in part as follows: "Howard, our new inspector of erection, will arrive at Henks & Henks on the 10th. He is quite young, but a very good man, and I have given him a letter to you, as he is to inspect the engines for his department on job 167,283. Get through with your work as soon as you can and report at the office."

Howard soon appeared and went at his work with all the ardor of youth. He made no end of trouble, and was voted a nuisance by the shop hands. At the end of the week the inspectors had completed their work and were on their way back, seated in the sleeping car. Howard was silent and absorbed. He kept figuring away on a pad until bed time. On account of his youth the manager of Ball & Ball did not impress him with as much awe as he did Jenks for instance, or Martin. These two had written up their reports and handed them in to the manager before Howard had turned up. The manager was looking extremely stern as he noted his appearance.

"You are late, Mr. Howard. Have you the report?"

"Yes, and it is made out at length, and everything is passed and all right, but I want to call your attention to the last page of the report. You will notice that I have made out a little table showing the cost of the inspection by Jenks and Martin and myself on the engines for our various departments on job No. 167,283. It amount to $162.00, not counting salaries at all, which is just three times as much as it should cost. The three of us went 200 odd miles to make an inspection of engines which any one of us was perfectly capable to make, at just one-third the actual expense, and very little if any time was saved. Now——."

"Mr. Howard, I make allowances for your being young, but the management of this concern is in the hands of men brought up in it, and the idea of one man inspecting for various departments is not one of its traditions."

"But, Mr. Manager, I am a stockholder in this concern, and

here is a waste of money which could be avoided. I inspect engines for the erection department, Jenks for the construction department and Martin for the motive department. If any one of us is qualified to inspect an engine for one department, he is certainly qualified to do it for another. No better results can be obtained from three of us doing this work than from one. Why not make an inspection department which will look after all materials and apparatus of the same nature?"

"Young man, you propose something which would not work at all. Remember that the directors of this company must be consulted. They have friends who like to have their friends at the head of departments, and they do not like to have any encroachment on their domain."

"But, Mr. Manager, it seems to me that this inspection business is all wrong. I worked like a dog for a year to find out about ropes. I got the whole subject down fine and knew all about the makers, and was thoroughly practical on the subject; then you turned me over to inspecting engines, and now Wallace is looking after rope, and passing stuff that is not fit to hang a dog with."

"Now Mr. Howard, I say again that I make good allowance for your youth, yet what you propose is utterly impracticable on account of tradition and cannot be considered by me. I must take up my letters now, good-bye."

"But, Mr. Manager, I am a stockholder."

"Good-day, Mr. Howard."

For Erection read Bureau of Steam Engineering.
" Motive Power " " " Construction and Repair.
" Construction " " " Equipment.
" Stockholders " Taxpayer; and see how the thing fits.

The Steam Dredger Vulcan.

BY EMILE GUARINI.

The *Vulcan*, one of the most powerful center-ladder, barge-loading dredgers ever built, was recently constructed in the yard of Messrs. Ferguson Brothers, at Port Glasgow, for the construction of new docks and the deepening of some of the older docks on the Liverpool estate of the Mersey Docks and Harbor Board, which involves a vast amount of dredging of sandstone, rock and clay. This vessel was launched complete, with steam up, ready to start work, propelled and worked by twinscrew engines. Her length is 207 feet; breadth molded, 42 feet; depth molded, 14 feet.

She has a dredging capacity of 1,000 tons per hour from a depth of 56 feet below water level. The main engines, which are employed for either propelling the vessel or driving the dredging gear, consist of two sets of triple-expansion surface condensing inverted direct-acting type, having three cranks, and are capable of indicating 1,250 horsepower. They are fitted with steam reversing gear, and have auxiliaries embodying all the latest improvements. Steam is supplied from two cylindrical return multitubular boilers, constructed under Lloyd's special survey. The compartments at the after end of the ladder well are arranged as coal bunkers and feed tanks, having capacities of 100 and 50 tons respectively. The dredger thus engined is capable of propelling herself at a speed of 8½ knots. Steam steering gear, of the Harrison type, is fitted at the after end of engine casing, and is controlled from wheel house, which is placed on the highest point of dredger, at the top of the main gear framing.

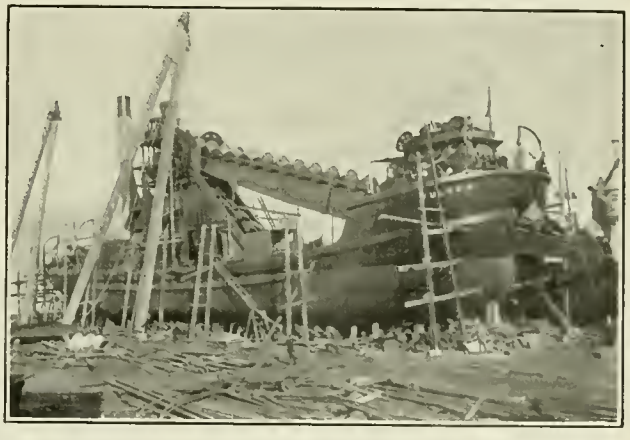
A complete installation of electric light is fitted throughout, large arc lamps being placed on deck for night work. Heavy elm beltings are fitted all round the vessel, also strong vertical fenders at intervals to take the wear of the barges lying alongside.

Separate accommodation is provided under deck for captain, engineers, crew and ladder men, all of which is roomy and thoroughly comfortable, special provision being made for light and ventilation.

Powerful steam winches are fitted at bow and stern of the vessel for manipulating the mooring chains and holding the dredger up to its work. Each winch is driven by an independent two-cylinder vertical engine. The forward winch is fitted in two sections, one in each side of the bow of the dredger, connected by shafting carried across the ladder well. The forward winch has four chain barrels with two rope warping drums. All chain barrels are provided with independent friction clutches and brakes, and can be worked separately or together, as required.

The dredging machinery is of massive design for working in the hardest materials that can be dealt with by bucket dredgers. The gearing is arranged to work the buckets at two different speeds, according to the nature of the material being dredged. All wheels, pinions, clutches, tumblers and bucket backs are of cast steel, the fast running wheels having helical teeth. The dredger buckets and links are of a specially strong design for working in hard material, each bucket having a capacity of 21 cubic feet, the connecting pins for the bucket chain being of manganese steel. The bucket ladder is suspended independently of the upper tumbler shaft.

The latter shaft is driven by double-friction spur wheels of large diameter, and capable of being adjusted to convey the necessary power to the buckets, according to the hardness of the material being worked. The hoisting gear for the bucket ladder consists of a heavy wire rope tackle, working in upper and lower sheave blocks, suspended from a crosshead fixed on a box-framing structure, built into the forward end of vessel.



THE DREDGE VULCAN BEFORE LAUNCHING.

The lower sheave blocks are connected to the bucket ladder by strong side rods. The wire rope is wound on a large grooved barrel, driven by gearing from a double-cylinder vertical engine, all placed under deck. The gearing between engine and barrel is of the "sun-and-planets" motion type, controlled by double friction brakes actuated by a compound lever for holding, heaving, or lowering the load as desired, the engine being free to run either with or without the load. The wheels and handles for working this gear are placed on deck under the control of the dredging master. A large steam derrick crane is fitted on deck for overhauling the buckets and links and for general purposes.

The bucket ladder projects in advance of the hull a distance sufficient to enable the vessel to dredge close up to the dock and quay walls, when buckets are lowered to a depth of 48 feet. She is capable of cutting her own flotation, and of dredging in any depth from her flotation level down to 56 feet.

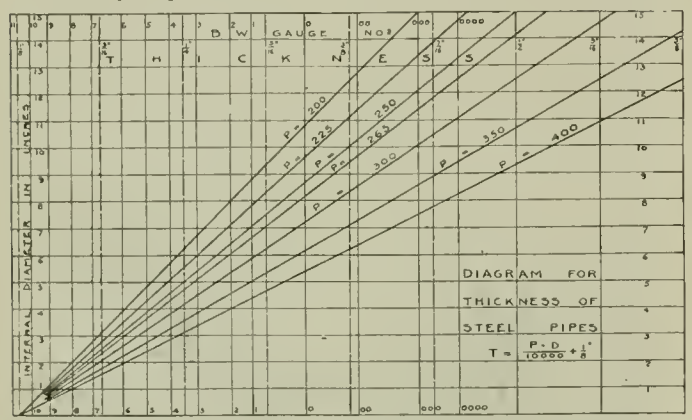
The hull is sub-divided into fourteen watertight compartments; the two sides of the hull forming the bow well at the forward end of the vessel, where bucket ladder projects, being strongly connected by a raised forecastle, constructed with heavy girder beams and strong bracing plates carried across above the ladder well. This forecastle is of a height to permit of the bucket ladder being raised for overhauling the lower tumbler, and to ensure the sag of the chain of buckets being above the bottom of the vessel. The bucket ladder and box framings for supporting

the chain of buckets and dredging gear have been constructed of the best class of girder work, all put together and efficiently connected with steel rivets closed by hydraulic pressure. Side chutes are arranged for discharging the dredged material over either side of the vessel into hopper barges, the lifting and lowering of each chute being worked by an independent engine. The regulation of the spoil to either side of the vessel is controlled by a strong flap door, fixed at the apex of the chutes, and is worked by gear from main deck.

The *Vulcan* went on trial four days after being consigned to the water. After adjusting compasses, she carried out her speed trials at Skelmorlie, attaining a mean speed of 8½ knots, this being half a knot in excess of that contracted for. She was constructed under the direction of Mr. Anthony G. Lyster, engineer-in-chief for the Mersey Docks and Harbor Board.

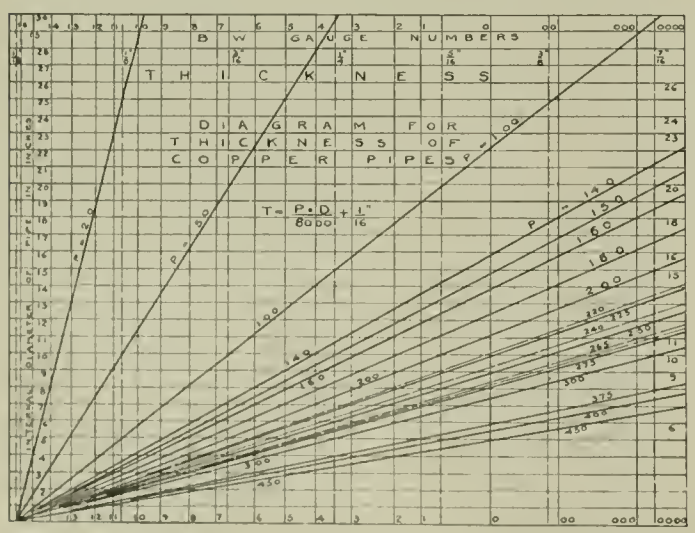
Standard Pipe Thicknesses.

Among the numerous standard specifications used by the United States Navy Department, two quite important ones deal with the



thickness of pipe. The first of these which we illustrate by diagram, gives the thickness in both Birmingham wire gauge and fractions of an inch for steel pipes of various sizes up to 15 inches in diameter, and with pressures varying from 200 pounds per square inch to 400 pounds. The thickness is calculated from the formula $T = \frac{P \times D}{10{,}000} + \frac{1}{8}$ inch.

The other illustration deals with the thickness of copper pipes of an internal diameter up to 30 inches, and gives the thickness of the pipe in B. W. gauge and fractions of an inch for pressures

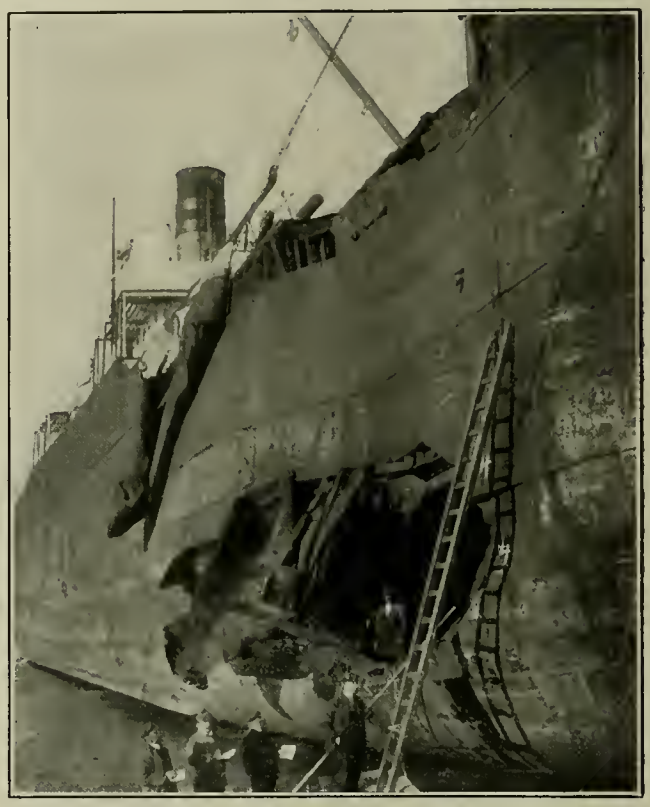


varying from 20 pounds per square inch to 450. The formula on which this calculation has been made is $T = \frac{P \times D}{8{,}000} + \frac{1}{16}$ inch.

A SERIOUS COLLISION.

The Norwegian steamer *Tordenskjold,* Captain Kroger, which was damaged in a collision with the Hamburg-American steamer *Euphemia,* October 23, at St. Antoine, some 40 miles above Quebec, was placed on Davie's dock, at Quebec, for temporary repairs. She is a vessel of 335 feet in length and was drawing, at the time of the accident, 23 feet 6 inches. She was on her passage from Sydney, C. B., to Montreal with a cargo of 6,000 tons of coal for the Dominion Coal Company.

The damages sustained by the *Tordenskjold,* as can be seen by the accompanying photograph, are very considerable. Besides



THE TORDENSKJOLD, SHOWING DAMAGE DUE TO COLLISION.

a large hole on her starboard side, where her plates have been twisted in, all her bulwark is badly torn or dented for a length of about thirty feet from her stem, and all her fore-parts on the starboard side are seriously pounded. In fact, the whole structure of the vessel has sustained considerable shaking up and will require a thorough overhauling.

She will be temporarily repaired and patched up with canvas, lumber and cement at Davie's docks, so as to allow her to take sea light, and it is understood that she will be taken to New York for permanent repairs. She may be called a total constructive loss.

A Canadian Fishery Cruiser.

BY J. O. WHITTEMORE.

The latest addition to King Edward's permanent fleet on this side of the water is the Canadian fishery protective cruiser *Canada,* which has recently arrived on her station. This craft is of more than passing interest, as she was designed and built for the special service of a fish patrol on the Dominion coasts. The craft is similar in type to the United States revenue cutters of the *Gresham, Algonquin,* and *Onondaga* class. She was launched about one year ago from Vickers Sons & Maxim's yard at Barrow, England, under the supervision of Chief Engineer D. M. Mooney, who has been acting chief of the *Canada* since she was commissioned.

The *Canada* is 210 feet long, 25 feet beam, and 14 feet deep.

She is built of mild steel, has a ram bow, and two decks. She is driven by two triple-expansion engines, with cylinders 15, 23½ and 38 inches in diameter, and a 24-inch stroke, at a working pressure of 180 pounds. She has two Scotch boilers under Howden's system of forced draft, and can develop 1,600 indicated horsepower with a speed better than 17

CANADIAN FISHERY CRUISER CANADA.

knots. Her auxiliary equipment is most complete. She has all the pumps usually found on the largest cruisers—See's ash ejectors, feed-water filters, evaporators, etc. The officers' mess rooms, cabins, pantry, bathrooms, etc., are on the lower deck aft. The captain's cabin is on the main deck in a deck house. The crew bunk forward on both decks. She has a full electric plant and a 25,000 candle-power searchlight on the bridge, which can pick up a poacher two miles off. Her armament consists of four quick-firing Maxims and two six-pounders. In her armory is a complete outfit of cutlasses, rifles, and revolvers, for her full complement of 60 men.

The *Canada* is rigged as a fore-and-aft schooner with pole masts. She has both hand- and steam-steering gear on deck and bridge. To chase smugglers in shore she has a large and fast steam launch, and four other boats. She is fitted with the submarine signal system, also with wireless telegraphy. The new boat, with her speed, searchlight, and other special equipments, is most admirably adapted to the purpose of policing the fishing grounds, and her coming adds greatly to the risk of illegal fishing.

Stranding of the Steamship Virginian.

Early in the fall of 1905 the large steamship *Virginian* of the Leyland Line ran ashore in the St. Lawrence river just above Quebec, while on her way to Montreal. The difficulty was due to very thick weather caused by heavy forest fires in the vicinity, which made it impossible for the pilot to see more than a short distance from the ship. The bottom was badly damaged, and it was some time before the vessel could be taken off. She was placed in dry dock by the George T. Davie Company of Levis, Quebec, and repairs made. The *Virginian* is an iron screw steamer measuring 422 feet in length, 41 in beam and 29 in depth. She has a net registered tonnage of 3,166, and 4,195 gross; was built in 1881 by the Palmers Shipbuilding Company of Jarrow, England; and is provided with a compound engine having cylinders 29 and 77 inches in diameter with a stroke of 60 inches. The ship is fitted with six bulkheads and has three decks. The photograph by Richards, of Montreal, shows her lying on the bank before being released.

A peculiar coincidence connected with her stranding was the fact that at about the same time the new turbine steamship *Victorian* of the Allan Line went aground in the St. Lawrence, due to the same cause, and for a time it was understood in shipping circles that both of the Allan line turbine steamers

STEAMSHIP VIRGINIAN AGROUND ABOVE QUEBEC.

were aground, because of the fact that the Leyland liner happened to bear the same name as the other Allan turbine liner.

The Sinking of the Steamship Doncaster.

Due to a collision in which she was struck amidships by a large steamship, the steamer *Doncaster*, of the Great Central Railway's passenger service, operating from Hull to New Holland, England, and thereby connecting the railways of Yorkshire with those of

STEAMSHIP DONCASTER SUNK AT HER DOCK.

Lincolnshire, was so badly damaged that when the captain ran her immediately alongside the dock she went down in shallow water. Due to the fact that the cabins and all accommodations were under water for some time before the ship could be raised and repaired, it was found necessary to renew almost all the fittings, including of course all the upholstery in the accommodations, before she could again be placed in service. Fortunately no one was injured at the time of the collision.

The *Doncaster* has a length of 160 feet, a beam of 18 feet 7 inches, and a depth of 8 feet 4 inches. Her tonnage is 216 gross and 165 net.

Marine Engineering

Published Monthly by
MARINE ENGINEERING
INCORPORATED.
17 Battery Place, - - NEW YORK
8 Finsbury Square, - - LONDON, E. C

H. L. ALDRICH, President and Treasurer

PROF. W. F. DURAND, Advisory Editor

SIDNEY GRAVES KOON, Editor

GEORGE SLATE,
Vice-President and Advertising Representative

Branch Offices. Philadelphia, Pa., Machinery Dept., The Bourse, S. W. Anness.
Boston, Mass., 170 Summer St., S. I. Carpenter.
Chicago, 34 Clark Street, Howard S. Moss.

TERMS OF SUBSCRIPTION.

	Per Year.	Per Copy.
United States, Canada and Mexico	$2.00	20 cents
Other countries in Postal Union	10/6	1/-

Entered at New York Post Office as second-class matter.

Copyright, 1906, by Marine Engineering, Inc., New York.
Marine Engineering is registered in the United States Patent Office.

Notice to Advertisers.

Changes to be made in copy, or in orders for advertisements, must be in our hands, in New York, not later than the 10th of the month, to insure the carrying out of such instructions in the issue of the month following.

The edition of the April issue of Marine Engineering *comprises 6,500 copies. We have no free list, accept no return copies and issue only enough to supply the regular demand, so that the 6,500 copies represent legitimate circulation.*

The Motor Boat Show.

With the closing on the evening of March 8 of the joint Motor Boat and Sportsmen's Show in Madison Square Garden was ended what will in all probability prove to be the last joint undertaking of this sort. The growth of the motor boat business has been so great and so rapid that exhibitors this year were much crowded, while those who had only engines to show and wished to show these engines in operation were actually shoved out of the space on the main floor, which they had previously occupied, and placed in the basement. Much dissatisfaction regarding both this displacement of their exhibits and the facilities in general which were accorded resulted in the introduction of a resolution at a meeting of the National Association of Engine and Boat Manufacturers looking to a correction of this state of affairs next year.

What was finally determined upon was to hold a separate Motor Boat Show about the middle of February, the Sportsmen's Show, under separate management, coming at a later date. It was, however, determined to discontinue the use of the large tank which has been so conspicuous a feature of the show during the last few years. This tank occupied an amount of space disproportionate to the benefits which it conferred, and the decision not to use it again was the result of numerous complaints of crowding, due to its immense size. All of the exhibits next year are to be on the main floor, except for the small exhibits in the balcony; and the engines which it is desired to operate will be run by illuminating gas, as the authorities will not permit in the building the use of gasoline for that purpose.

The result of these changes ought to render the show of 1907 much superior in many ways to its predecessor, and of much more value to the designers and builders of the different appliances exhibited; for it will not only afford them immensely greater space, all on one floor, but it will also make available for their use every bit of space in the building, without the encroachment of another show of somewhat kindred nature but yet radically different, and will allow the concentration of exhibits of one sort in such a manner as to best set forth the salient features of each, both in itself and in its relation to the others.

Power Doors for Watertight Bulkheads.

In the new British battleship *Dreadnought,* which has attracted a vast amount of attention on both sides of the Atlantic, it is understood that all openings of any sort in the watertight bulkheads below the water line have been abolished. Not only this, but with no openings whatever in her armor sides, each of the watertight compartments will be absolutely self-contained, and invulnerable to any but the heaviest projectiles. This decision on the part of the British Admiralty has given rise to much speculation, for it is needless to say the arrangement of the vitals of a ship without the possibility of inter-communication from one part to another except by way of the berth deck, must needs give rise in operation to an immense amount of annoyance, and might easily lead to a great deal of confusion.

The rather remarkable tests of power doors described in another column of this issue would seem to indicate that with systems now available the method adopted by the designer of the *Dreadnought* is to a certain extent uncalled for. When a door can be closed in the face of a coal bunker and can actually cut its way down through the coal to a sufficient degree to render the opening almost absolutely waterproof, as was done in the tests in question, and when, furthermore, this door can be handled from any one of a plurality of stations situated far above any danger zone from in-rushing water, it would seem that the problem of rendering the watertight compartments of a ship watertight in fact as well as in name under all conditions of service has been so successfully achieved that little remains except to perfect a few details which might make for somewhat smoother action. These doors do not crash down through the coal, as is supposed in some quarters, but their motion is gradual and the force applied increases with the resistance until a point is reached at which an automatic cut-off releases the motor momentarily from further work. If in-rushing water should attain such volume and impetuosity as to throw any of the coal from beneath the door the automatic arrangement of the electric connections would at once re-start the motor upon the removal of the resistance due to the coal, and the door would proceed to seat itself without the

necessity of any further action on the part of any one connected with the organization of the ship.

It is obvious that when these doors are placed in any watertight bulkheads other than those leading from coal bunkers they could close immediately, without any delay occasioned by stoppage due to impediments. This being the case, the neglect to fit some such system on the great battleship above mentioned appears to us to have been in a large measure an error in design.

Delays in Warship Construction.

In another column we print a communication from a correspondent, in which he refers to the delay of more than a year in connection with beginning the construction of the two battleships authorized at the last session of congress. This delay has been not without its redeeming features, although its purpose (avowedly to obtain the permission of congress to increase the displacement of the vessels from 16,000 to 18,000 or 20,000 tons) has not borne fruit. On the original displacement, however, a design has now been prepared in which the ship carries eight 12-inch guns arranged in pairs in four turrets on two levels in such manner that the entire main battery may be trained upon one broadside. This gives a fire much superior to that shown in some of the "guesses" which have been made with regard to the disposition of the battery of the *Dreadnought,* and fully equal to that shown by the best disposition given by any of these guesses.

As a matter of fact, however, the delay is operating very adversely to the interests favoring the continued increase of the navy, not only by reason of the fact that a year has been lost which might have been put to good advantage in construction, but also because of the fact that congress has in some way obtained the idea that as we have two ships which are not yet begun, it will not be necessary to authorize any more this year, or at any future time until they shall be begun. In this way the necessary annual increase of the navy seems in danger of being passed by, with a consequent relative strengthening of the hands of our (potential) enemies.

This question of delay, not only in the department, but among the shipbuilders of the country, has long been one of extreme importance. Sometimes it is the result of circumstances over which the builders have no control, such for instance, as labor troubles, or the non-delivery of armor upon specified time; but in other cases we believe, from indications which have reached this office, the question of poor management enters very largely into the problem. There are now actually under construction for the United States Navy twelve battleships ranging from 13,000 to 16,000 tons in displacement, not counting the *Rhode Island,* which went into commission in February. Of this number not less than six are at the present time uncompleted, although the contract date of completion has past. Of these six, four were under contract to be completed in February and March of 1904—two years ago—and it is doubtful if the four will all be ready for commission before next fall. This showing is one which is not at all to the credit of the builders, although in justice to them it may be mentioned that some of the delays have been caused by alterations in design, made by the government after the ships were well under way.

So long as we continue to require five or six years after the signing of the contract before the ship is delivered to the government, just so long will we be at a serious disadvantage as compared with powers like Germany and England, which build such ships in three and two years respectively. This explains why, with nearly twice as many battleships under construction as England, our navy is increasing less rapidly than theirs.

The Merchant Marine.

From the vice-president of the Merchant Marine League of the United States:

"The recent development of the steam turbine marks an epoch in marine construction which we in this country have been slow to realize. Tests have shown that economy is secured in the turbine over the reciprocating engine from speeds not lower than fifteen knots up. At the moment this does not take in speeds below fifteen knots, or the tramp freight ship, but progress is so rapid in these days that the inventive and experimental mind is at work to secure to the turbine at the lower speeds an economy over the reciprocating type which has been in use for the past seventy-five years; in which Great Britain as the great maritime power, is equipped with some 12,000,000 tons of ships, while we have about 500,000.

"It seems to me that a new epoch for steam propulsion on the sea is at hand, and this is certainly an auspicious period for a departure in this direction. We are about to celebrate in New York City, on behalf of the whole country and for the pleasure and benefit of the whole country, a centennial of the beginning of steam navigation in the world, the initial point of which was Fulton's experiment with the steamer *Clermont* on the Hudson River in 1807.

"Is not this the time for the country to start afresh in the race in this new order of propulsion for our merchant marine and for our navy? England, on the one hand, will have to remake her ocean-going outfit, as will the other great maritime nations of the world. The United States, on the other hand, is in a position to build from the foundation up.

"The United States is like the builder who has in his possession the plans of his architects, while the money with which he is to construct his building is in the bank and the site unencumbered. Every dollar that he puts into the building will be an investment sure to return him an income, and he is in a position to so arrange the structure that it will exactly suit him.

"We are in the same position as a nation in relation to our merchant marine. I feel that this is a matter which the American people cannot longer ignore, and they certainly will not if they follow the advice of the best posted and most intelligent marine engineers."

ABSTRACT OF RULES AND REGULATIONS OF THE BOARD OF SUPERVISING INSPECTORS OF UNITED STATES STEAMBOAT INSPECTION SERVICE.

EDITION OF AUGUST 3, 1905.

ARRANGED BY HARRISON S. TAFT.

1. Bulkheads.

1. Every sea-going steamer and every steamer navigating the Great Lakes, carrying passengers for hire, shall have not less than three water-tight athwartship bulkheads, extending to the main deck in single-decked vessels, but to the deck next below the main deck in all other classes of vessels. In wooden hulls they shall be fastened to suitable framework, which framework must be securely attached to the hull and calked. In metal hulls they shall be well secured to the frame and be strengthened by angle irons spaced not more than two feet from center to center. One of the bulkheads must be placed forward and one abaft of the engine and boiler space. The third or collision bulkhead must be placed not nearer than five feet from the stem of the vessel.

2. Metal bulkheads must not be less than one-fourth inch in thickness. Wooden bulkheads must be of equal strength and be covered with plates not less than one-sixteenth inch in thickness.

3. All steam ferryboats, carrying passengers for hire, and navigating bays, sounds or rivers, shall be supplied with a sufficient number of water-tight bulkheads to float the vessel if the largest compartment is filled with water.

4. Steam vessels of one hundred tons burden or under, engaged in the coastwise bays and harbors of the United States, may carry passengers or excursions on the ocean or upon the Great Lakes for a distance not exceeding fifteen miles from the mouths of such bays or harbors, without being required to have the above three water-tight athwartship bulkheads, if in the judgment of the United States local inspectors of steam vessels such steamers shall be safe and suitable for such navigation without danger to human life, and have one water-tight collision bulkhead not less than five feet abaft the stem of said steamer.

5. A valve worked from the main deck must be fitted to all hold bulkheads.

2. Woodwork from Boilers.

1. There shall be a clear space between the boiler and the woodwork of not less than 6 inches at the sides and 4 inches at the top for external-heated boilers, but not less than 4 inches at both sides and top for internally-heated boilers.

2. All boilers shall have a clear space of 2 feet at their back and ends opposite the back-connection door. On vessels constructed of iron or steel with metal bulkheads the distance between the back-connection doors and such metal bulkheads shall not be less than 16 inches.

3. All boilers placed in wooden steamers shall have a clear space of at least 8 inches between the underside of the cylindrical shell and the floors or keelsons. On all other steamers the boilers shall be so placed as to permit of proper inspection of their under sides.

4. All woodwork or other ignitible substance approaching within 12 inches of the boiler or smokestack (unless such boiler or smokestack is covered with good non-conducting material) shall be suitably sheathed with metal over non-combustible material. All woodwork or other ignitible substance in or around the fireroom is to be properly protected by metal or asbestos sheathing.

3. Steps, Ladders, Extra Steering Apparatus.

1. Every steamer or barge carrying passengers shall be provided with suitable ladders to enable passengers to descend conveniently to the lifeboats, such ladders being placed near each side of the vessel.

2. Every steam vessel shall be provided with sufficient means of escape from the lower to the upper deck, or vice versa, and every steamer of 50 tons or over carrying passengers shall be provided with permanent stairways forward and aft, except where said stairways on towing boats would interfere with the towing bitts.

3. Extra steering apparatus, consisting of relieving tackles or tiller, must be provided for all steamers.

4. Lifeboats.

(*a*) Lifeboats on Passenger Vessels.

1. All vessels carrying passengers for hire, shall be provided with lifeboats according to the following table; except that no vessel shall be required to have more boat capacity than sufficient to carry all the passengers and crew allowed by the certificate of inspection.

2. The capacity of each and every lifeboat shall be determined by the following rule: Measure the length and breadth of each boat outside of the planking or plating, and the depth inside at the place of minimum depth. The product of these dimensions, multiplied by 0.6, resulting in the nearest whole number, shall be deemed the capacity of said respective lifeboat in cubic feet. To determine the number of passengers a lifeboat is to carry, divide the result by 10 for ocean, lake, bay and sound steamers; but by 8 for river steamers. All lifeboats must have sufficient room, free-board and stability to carry said number of passengers in safety.

3. All lifeboats shall be substantially built, the joints and seams being double riveted throughout. Only countersunk-headed rivets will be allowed in the construction of metallic lifeboats. They shall have air-tight tanks of

TABLE I.—CAPACITY OF LIFEBOATS.

Total Cubical Capacity of Lifeboats Required on Passenger Vessels Navigating Waters as Follows:

RIVER STEAMERS.	Navigating the Red River of the North and Rivers Flowing Into the Gulf of Mexico.	Navigating Rivers Flowing Into the Atlantic or Pacific Ocean and their Tributaries.
Gross Tons.	Capacity in Cubic Feet.	
Not over 10	75	75
10 " " 30	90	90
30 " " 50	120	120
50 " " 100	135	135
100 " " 150	165	165
150 " " 300	240	360
300 " " 600	360	540
600 " " 900	480	720
900 " " 1,200	600	900
Over 1,200	720	1,080

FERRYBOATS.	
Gross Tons.	Capacity in Cubic Feet.
50 not over 300	120
300 " " 600	240
Over 600	360

On ferryboats of more than 300 gross tons, one-half the boat capacity required may be substituted by its equivalent in approved life-rafts.

LAKE, SOUND, BAY STEAMERS, OCEAN-GOING VESSELS.	Navigating the Great Lakes, Sounds, and Bays.	Navigating the Oceans.
Gross Tons.	Capacity in Cubic Feet.	
Not over 10	75	75
10 " " 30	90	90
30 " " 50	120	120
50 " " 100	135	135
100 " " 150	165	165
150 " " 200	360	540
200 " " 300	540	720
300 " " 400	720	1,080
400 " " 500	900	1,260
500 " " 1,000	1,080	1,620
1,000 " " 1,500	1,260	1,800
1,500 " " 2,000	1,440	2,160
2,000 " " 2,500	1,620	2,340
2,500 " " 3,000	1,800	2,700
3,000 " " 3,500	1,980	2,880
3,500 " " 4,000	2,160	3,240
4,000 " " 4,500	2,340	3,420
4,500 " " 5,000	2,835	
5,000 " " 5,500	3,330	3,870
5,500 " " 6,000	.....	4,320
6,000 " " 6,500	.....	4,770
6,500 " " 7,000	.....	5,220
7,000 " " 7,500	.....	5,670
7,500 " " 8,000	.....	6,120
8,000 " " 8,500	.....	6,570
8,500 " " 9,000	.....	7,020
9,000 " " 9,500	.....	7,470
9,500 " " 10,000	.....	7,920
10,000 " " 10,500	.....	8,145
10,500 " " 11,000	.....	8,370
11,000 " " 11,500	.	8,595
11,500 " " 12,000	.....	8,820
12,000 " " 12,500	.....	9,045
12,500 " " 13,000	.....	9,270
13,000 " " 13,500	.....	9,495
13,500 " " 14,000	.....	9,720
14,000 " " 14 500	.....	9,945
14,500 " " 15,000	.....	10,170
15,000 " " 15,500	.....	10,395
15,500 " " 16,000	.....	10,620
16,000 " " 16,500	.....	10,845
16,500 " " 17,000	.....	11,070
17,000 " " 17,500	.....	11,295
17,500 " " 18,000	.....	11,520
18,000 " " 18,500	.....	11,745
18,500 " " 19,000	.....	11,970
19,000 " " 19,500	.....	12,195
19,500 " " 20,000	.....	12,420

Steamers above 5,500 gross tons navigating the Great Lakes, sounds and bays shall be furnished with an additional boat of not less than 495 cubic feet capacity for each additional 500 tons burden or fraction thereof.

Ocean-going vessels of over 20,000 gross tons shall be provided with an additional boat capacity of 225 cubic feet for each additional 500 gross tons, or fraction thereof.

Boats required by the above table on ocean vessels of 150 gross tons and over shall be of suitable dimensions and of not less than 180 cubic feet capacity.

1. At least one boat shall be of metal, unless exempted by the proper authorities.
2. All vessels of 50 gross tons and upward must have one working boat in addition to the boats required by the above table.
3. One-third of the boat capacity required on any vessel may be substituted by its equivalent in approved life-rafts or approved collapsible (folding) lifeboats.

1

sufficient capacity to float them when full of water and at the same time being loaded to allowed capacity. The joints of said tanks shall be both riveted and soldered. All metallic lifeboats shall be furnished with an automatic plug.

4. Metallic lifeboats of 20 feet length and under shall be constructed of metal of not less thickness than No. 18 Birmingham wire gauge. Boats 20 to 24 feet in length shall have a thickness of metal of not less than No. 16 Birmingham wire gauge for their middle half length and not less than No. 18 for their ends. Boats longer than 24 feet shall be of proportionally thicker material.

5. Each and every lifeboat shall have its cubical contents painted on the stem in black letters and figures not less than three-fourths inch high on a white ground. There must also be some plate or other device giving the number of persons each boat will carry.

6. All lifeboats on vessels carrying passengers for hire, must, if practicable, be carried under substantial davits or cranes, with two separate davits or cranes for each boat so carried, or with a single crane for each boat when such single crane is properly adapted to lower said boat. If it is not practicable to carry all the lifeboats under davits or cranes, the remainder must be stowed near at hand, so as to be easily and readily launched when required. All boats under davits must be arranged so that they can be simultaneously launched. Such davits or cranes, and the blocks and the fall thereof, on all passenger vessels except ferryboats, must be of sufficient strength to carry the boat with its full load.

(*b*) Lifeboats on Non-Passenger Vessels.

1. All vessels of less than 50 gross tons, and not carrying passengers, must be equipped with boats or rafts as in the opinion of the inspectors may be necessary to secure the safety of all persons on board in case of disaster.

2. All vessels of 50 gross tons or over not carrying passengers shall at all times be equipped with sufficient boat capacity to carry the crew of said vessel with safety.

3. Steamers of less than 150 gross tons, while engaged exclusively in harbor towing, may substitute one or more life-rafts for the lifeboats required, when the lifeboats interfere with the practical operation of said steamers, and such substitution can be made with safety. It being understood that when such vessels engage in service other than harbor towing they must be equipped with boats as required by the Rules and Regulations.

(*c*) Lifeboats for Small Steam Vessels.

1. The lifeboats referred to in table No. 1 for passenger steamers of 10 tons or under must be either carried or towed at all times when said vessels are being navigated with passengers on board.

2. All open steam launches or other steam vessels of 5 gross tons or less, used for pleasure purposes only, shall not be required to carry a lifeboat.

5. Life-Rafts.

1. The circumferential as well as the longitudinal seams of life-raft cylinders must be riveted and soldered. Only counter-sunk-headed rivets shall be used in the construction of said rafts.

2. The frame work connecting the cylinders of metallic life-rafts must be substantially built and capable of resisting the strain which tends to break the cylinders apart when the raft is broadside on in a surf or in a seaway.

3. Life-raft cylinders if over 15 feet in length must be constructed of metal of not less thickness than No. 18 Birmingham wire gauge. If 15 feet or less in length, metal of not less thickness than No. 20 Birmingham wire gauge is to be used. The retaining bands which secure the cylinders to the frames should be made in halves so that the cylinders may be detached without difficulty for the purpose of inspection, cleaning and painting.

4. All life-raft cylinders, except those 6 feet or less in length, must be divided by water-tight bulkheads into not less than three compartments of equal lengths, and each compartment shall be provided with a suitable air pump connection, of one-half inch diameter, fitted with an air-tight cap.

5. The inspection of a metallic cylindrical life-raft will include the testing of each compartment with an air pressure of 5 pounds to the square inch.

6. There shall be stencilled in a conspicuous place on each life-raft the number of persons said life-raft can carry, as hereinafter provided.

7. All life-rafts except the "Carley life-float" shall have an actual buoyancy of 18$7\frac{1}{2}$ pounds upon oceans for every person allowed, and 156 pounds upon lakes, bays, sounds, and rivers for every person allowed. For the Carley life-float, the figures are respectively 145.5 and 121 pounds.

6. Life-Preservers.

1. Every vessel shall be provided with one good life-preserver for each and every person allowed to be carried on said vessel by the certificate of inspection.

2. All ferryboats shall be equipped with a life-preserver (or float where the same is allowed by law) for every 7 square feet of passenger deck surface on single-deck ferryboats and for every 12 square feet of such deck surface on ferryboats having more than one passenger deck. Said life-preservers or floats shall be distributed in the most accessible places, where they can be reached at all times.

3. All such life-preservers shall not be less than 52 inches in length when measured laid flat. Every cork life-preserver shall contain an aggregate weight of at least 6 pounds of good cork, and shall be capable of sustaining for a continuous period of twenty-four hours an attached weight so arranged that whether the said weight be submerged or not there shall be a direct downward gravitation pull upon said life-preserver of at least 20 pounds.

4. All life-rafts and life-preservers made in whole or in part of loose granulated cork shall be excluded from use on all vessels. All "kapok" life-preservers shall also be excluded from use on all vessels.

7. Line-Carrying Guns, Rockets, and Projectiles.

1. All ocean steam vessels carrying passengers, except vessels of 150 gross tons and under, shall be provided with a line-carrying projectile and the means of propelling same.

2. Where a life-gun is carried it shall be provided with at least three projectiles and the necessary lines to connect such projectiles, and at least three charges of navy cannon powder.

3. When approved rockets are used instead of guns, there shall be in every case at least three of said rockets.

4. All steamers that are required under law to carry line-carrying projectiles and the means for propelling them shall be supplied auxiliary thereto with at least 800 feet of three-inch manilla line for vessels of 100 to 500 gross tons, and 1,500 feet of said line for steamers above 500 gross tons. Such auxiliary line is to be kept always ready for use in connection with the gun or rocket, and said lines shall not be used for any other purpose.

8. Drags or Floating Anchors.

1. Drags or floating anchors shall be constructed so as to be capable of being compactly stowed near the head of the ship.

2. Steamers navigating the ocean must be provided with at least one drag, of area as follows: For steamers of 400 gross tons and under, not less than 25 superficial feet; for steamers of over 400 gross tons, the area of the drag shall not be less than that determined by adding to 25 square feet 1 square foot for each additional 25 gross tons above 400 tons.

3. Steamers of over 5,000 gross tons may be equipped with two or more drags, provided the total area is not less than that required by said rule. Steamers whose routes do not extend off anchorage are not required to have drags or floating anchors on board.

9. Steam Whistles.

1. All steam whistles shall be placed not less than 6 feet above the top of the pilot house of steam vessels where the height of the smokestack will admit the attachment of said whistle below its top (when not hinged for passing under bridges).

2. Upon steamers navigating the Red River of the North and rivers whose waters flow into the Gulf of Mexico, and also steamers of less than 100 gross tons, the steam whistles shall be placed not less than two feet above the tops of the pilot houses.

3. All double-end ferry steamers, and steamers similarly constructed shall have steam whistle both fore and aft of the smoke pipe, so that the steam, when the whistle is blown, can be seen from either end of the steamer.

4. All floating structures, such as steam elevators (propelled by their own motive power) are to have their whistles located on the front side of such superstructure having an elevation higher than the pilot house of said vessels.

10. Fog Bell.

The efficient fog bell required on vessels by law shall be held to mean a bell not less than 8 inches in diameter from outside to outside and constructed of bronze or other material equal thereto in tone and volume of sound.

11. Fire Apparatus.

(*a*) Barrels, Buckets, Axes.

1. Fire buckets, barrels, or tanks, must, when practicable, be constantly filled with water and be in such positions on board as shall be most convenient for extinguishment of fire.

2. All axes must be located so as to be readily found in time of need. They must not be used for general purposes, and must be kept in good condition.

TABLE 2.—BARRELS, BUCKETS, AXES.

Class of Vessels.	Steamers Carrying Passengers.			Freight and Towing.		
Gross Tons.	Barrels.	Buckets.	Axes.	Barrels.	Buckets.	Axes
Not over 10	..	2	1	..	2	1
Over 10 " " 25	..	4	1	..	4	1
" 25 " " 50	1	6	2	1	6	2
" 50 " " 100	1	8	2	1	8	2
" 100 " " 200	2	18	4	1	12	2
" 200 " " 500	4	24	6	2	15	3
" 500 " " 1 000	6	35	8	3	20	4
" 1,000	8	50	10	4	25	5

Tanks of suitable dimensions and arrangements, or buckets of sufficient number, may be substituted for barrels on all vessels. Five buckets shall be considered as equivalent to one barrel.

(*b*) Steam Pipes to Holds.

1. The main pipes and their branches, on steamers carrying passengers or freight, to convey steam from the boilers to the hold and separate compartments of the same, except the cabins, shall not be less than 1½ inches in diameter.

2. Steam pipes of not less than ¾-inch in diameter must be led to all lamp lockers, oil rooms, and like compartments. Said lamp lockers, oil rooms and compartments being wholly and tightly lined with metal.

(*c*) Fire Pumps.

1. Steamers required to be provided with double acting steam fire pumps, or equivalents for throwing water, shall be equipped with such pumps, according to their tonnage, as follows: Steamers under 3,000 tons shall have not less than one-third of one cubic inch pump cylinder capacity for every gross ton. Steamers over 3,000 tons shall have pump cylinders of not less than 1,000 cubic inch capacity.

2. Upon such steamers fire mains shall be led from the pumps to all decks, with a sufficient number of outlets, arranged so that any part of the steamer can be reached with water with the full capacity of the pumps and by means of a single 50 foot length of hose from at least one of said outlets. Every such pump shall be fitted with a gauge and a relief valve adjusted to lift at 100 pounds pressure.

(*d*) Fire Hose.

1. Fire hose shall in no instance be less than 1½ inches in internal diameter.

2. Steamers of 15 tons and under may use hose of ¾-inch internal diameter, but in no case shall it be less than the discharge opening of the pumps. Open boats of less than 10 gross tons that are fully equipped with buckets shall not be required to carry hose.

3. At least one length of such hose shall be kept at all times attached to each outlet of the fire main and provided with a suitable nozzle.

(*e*) Fire Extinguishers.

Fire extinguishers must be located so as to be most convenient and serviceable in case of need.

TABLE 3.—FIRE EXTINGUISHERS ON STEAMERS CARRYING PASSENGERS.

Gross tons.....	Under 50	50 to 100	100 to 500	500 to 1,000	Over 1 000
Number of extinguishers....	1	2	3	6	Not less than 8

(*f*) Ferryboats.

All ferryboats shall be provided with the same fire apparatus required on passenger steamers of equal tonnage.

12. Steamer's Name on Equipments.

All the equipments of a steamer, such as buckets, hose, axes, boats, oars, rafts, life-preservers, floats, barrels, and tanks, shall be painted or branded with the name of the steamer upon which they are used.

13. Equipment for Barges.

1. Barges carrying passengers on any routes shall have a life-preserver or float for each and every person allowed to be carried, and in addition thereto shall be supplied with 10 buckets, 2 barrels of not less than 40 gallons each, 3 axes, 1 hand fire pump, capable of discharging 100 cubic inches of water at each stroke, and sufficient length of regulation hose to reach to all parts of the vessel. Also two yawl boats of not less than 120 feet capacity each.

2. All barges in tow of steamers used for transferring persons on any lake, bay, sound or river shall be provided with the same life-saving appliances as required for passenger steamers.

3. All barges carrying passengers shall be inclosed by a good and substantial rail not less than 3 feet high.

4. Every barge carrying passengers in tow and engaged in excursions, shall be supplied with one life-preserver or one float for each person carried, and must have ten buckets, three axes, and two yawl boats of not less than 100 cubic feet capacity each, one of which boats must be manned and towed in such a manner as to best afford prompt relief and assistance in case of accident or disaster.

14. Sail-Vessel Equipment.

Sail vessels of over 100 gross tons carrying passengers on the ocean or on the high seas are to be equipped with a life-preserver for every person on board, passengers and crew, and with lifeboats in accordance with the requirements of the rule applying to ocean steamers carrying passengers.

15. Ferryboat Equipment.

1. All ferryboats of 50 gross tons or over shall be equipped with such lifeboats, life-rafts, outside ladders, and other means of escape, in case of disaster, as in the opinion of the inspectors, shall meet the requirements of each particular case.

2. In no case shall the cubic feet of boat capacity be less than that provided in Table No. 1.

16. Car Ferries.

All steamers, or barges in tow of steamers, used for transferring railroad passenger cars on any lake, bay, sound or river, with passengers in cars, shall be required to have the same life-saving appliances as required on passenger steamers.

17. Excursion Steamers and Barges.

1. Passenger steamers making excursions on the Great Lakes, bays or rivers, or on waters of the Atlantic and Pacific coasts and rivers flowing into the same, and rivers whose waters flow into the Gulf of Mexico, shall have, in addition to their regular life-saving equipments, a life-preserver (or float where the same is allowed by law), or their equivalent in other approved life-saving appliances, for each additional passenger allowed, over said vessels' ordinary allowance.

2. Steamers making excursions under a special permit must have at least one lifeboat or life-raft, in addition to their regular required equipment, so carried as to best secure the safety of those on board in case of disaster.

18. Legal Draft.

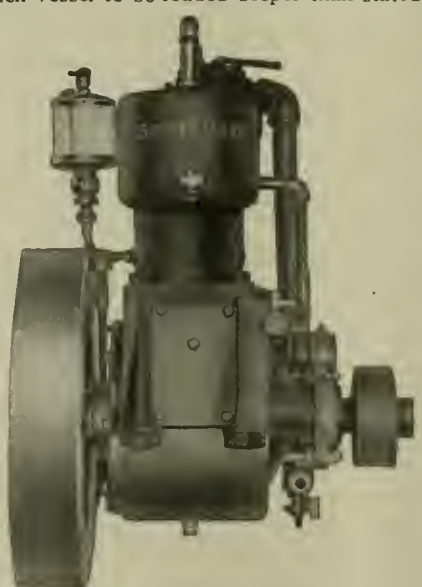
The owner, agent or master of every inspected sea-going vessel shall indicate the draft of water at which he shall deem his vessel safe to be loaded for the trade she is engaged in, which limit, as indicated, shall be stated in the vessel's certificate of inspection, and it shall be unlawful for such vessel to be loaded deeper than stated in said certificate.

ENGINEERING SPECIALTIES.

Sheffield Single Cylinder Four-Cycle Marine Engine.

Realizing the constant increasing demand and the usefulness of a practical and inexpensive power for small boats, yachts, luggers, etc., Fairbanks, Morse and Company, Chicago, have brought out a four-cycle engine of the simplest possible construction, with as little weight as is possible in modern engine practice. The type is vertical, with an inclosed crank case made with movable bearing plates, in which are mounted movable liners. The base is provided with hand hole plates, affording easy access for adjusting and inspection. The crank case being closed and oil tight, the engine is operated on splash lubrication. An entirely different method, however, is used from that ordinarily followed, as there is arranged inside of the base an oil separator, removing any heavy or foreign properties from the oil, and preventing them from re-entering the bearings.

The cylinder and head are cast in one piece, and water-jacketed. The valve chambers and valves are also water-jacketed. All valves are readily removed by loosening a bolt and swinging off the cover. The ignition is of the jump spark type. Commutator is independent, removable and renewable, arranged to be shifted to vary the time of ignition. The mixer is of the



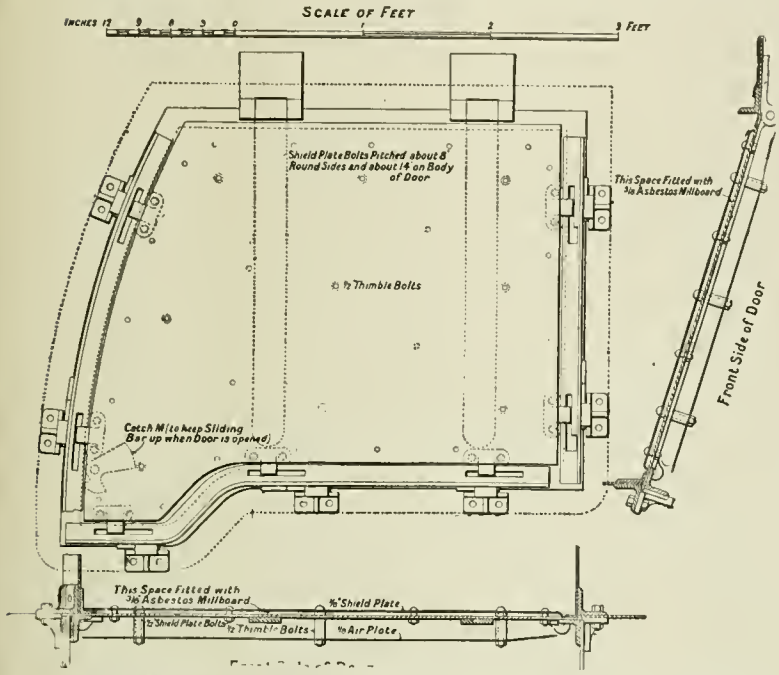
float feed carbureter type, arranged with lever throttle for varying the quantity of mixture admitted to the engine. The regulation is such that the engine has a wide range of speed.

A small circulating pump is attached to the engine for

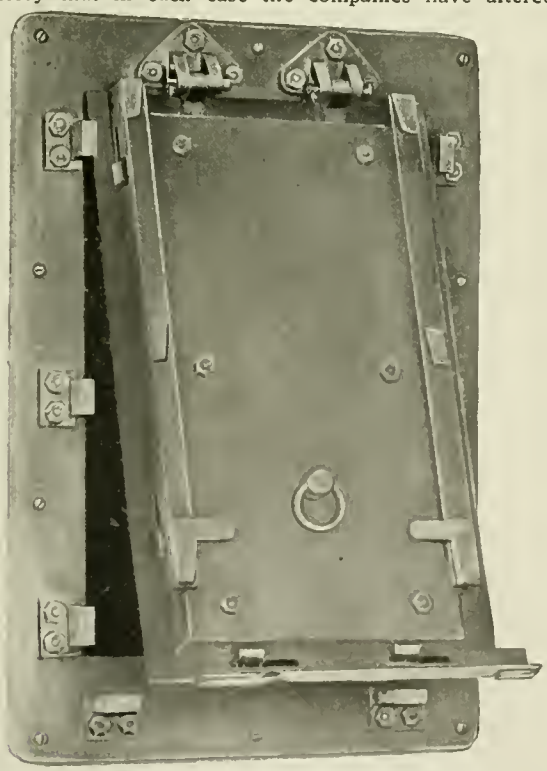
assisting circulation of the cooling water through the engine jacket. The gearing is cut and runs in an oil bath, thus making it quiet and reducing wear to a minimum. The crank shaft is of nickel steel. Connecting rod is drop forged. The size of engine now ready for the market is 4½ H. P.

Silley's Patent Smoke Box Door.

One of the most successful marine patents introduced during the past year, and which was awarded a gold medal at the Naval and Shipping Exhibition, is Silley's patent smoke box door. This


Scale of Feet
Inches 12 9 6 3 0 1 2 3 Feet
Shield Plate Bolts Pitched about 8" Round Sides and about 14 on Body of Door
This Space Fitted with ½" Asbestos Millboard
½" Thimble Bolts
Front Side of Door
Catch M (to keep Sliding Bar up when Door is opened)
This Space Fitted with ½" Asbestos Millboard
½" Shield Plate
½" Shield Plate Bolt
½" Thimble Bolts
½" Air Plate

door was put on the market about a year ago, after a severe trial in four different companies' ships, and the results were so satisfactory that in each case the companies have altered the



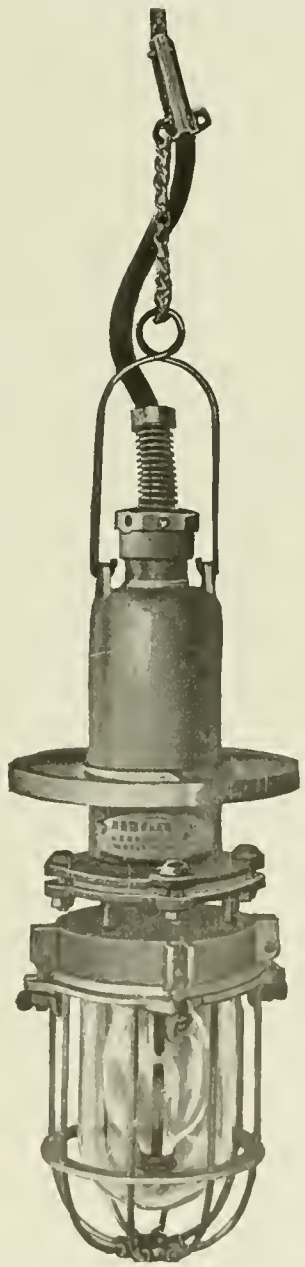
whole of the existing doors in these ships; within the last four months something like 1,200 of these doors have been ordered and specified.

It is stated that in cases where old fittings have been taken off and these doors substituted, greater efficiency has been obtained. Other advantages are: the reduction of speed on the fan engine of twenty percent, due to the smoke box doors being air-tight; the total absence of flaming at the funnel caused by gases in the smoke box door, the incoming air causing reignition of the gases in the route of the funnel, often with disastrous results; and no continual removals of catches.

Not only are these doors being adopted quite universally in England, but also in America, while arrangements have just been completed for their manufacture and fitting in Germany, France, Italy, Japan and other countries. The owners of this invention are the Air-Tight Smoke Box Door Syndicate. Mr. W. Carlile Wallace, Box 161, Tenafly, N. J., is the American representative.

Yale Submarine Electric Search-Light.

Owing chiefly to the fact that comparatively few intelligent persons have ever ventured to don diving armor and descend be-



low the surface, an air of mystery has come to enshroud the work of a submarine diver. In the shadow of a ship's hull, or an obstruction, or at depths of 50 feet and over, there exists an impenetrable gloom even with fairly clear water; while in the usual

dirty harbor the sun's rays never reach the bottom. In order to render the services of a diver of real value in making durable repairs it has been found necessary to considerably change the methods of operation and equipment. The question of light, the first step, is claimed to have been solved by the use of the powerful Yale submarine electric lamp, placed upon the market by the Chicago Pneumatic Tool Company. The complete equipment is designed to be placed aboard a ship in its own chest ready for use. The light from this lamp illuminates brightly a space the size of a large room. The lamp consists of a watertight metallic case inclosing a mechanism and regulator arranged so that when the lamp is submerged it will give forth from the glass chamber at its lower end a most brilliant clear light, better than the average street arc lamp. When in use the diver may carry the lamp about by means of the circular guard-handle, set it down, or suspend it in a convenient manner directly by the cable, no ropes being required. Its weight under water is only a few pounds, just enough to keep in position in a current or tideway. The cable conducting the current to the lamp leads to the surface and thence to a combined junction and switch plate controlled by the diver's attendant. From this plate, connection is made to a neighboring electric circuit, storage battery, or small generator outfit supplying the electric power. Compact, of few parts, and simple in operation, these submarine outfits afford means for use aboard ship, about a dockyard, mine, water-works, engineering construction, wherever a perfect light is desired for use under water or in a gaseous atmosphere.

TECHNICAL PUBLICATIONS.

Marine Engineering. The calculations, designing and construction of the modern marine steam engine, including marine steam turbines. A manual of the most recent practice for the use of engineers. By Hermann Wilda. Size 17½ by 24 inches. Plates, sixty-four, covering about 1200 illustrations. Hannover, 1904. Gebrüder Jänecke. Price $14.00.

This remarkable collection of drawings covering every phase of the construction of marine engines and accessories gives a very wide range of practice from English, German and American yards, and in very considerable detail. Nearly every engine illustrated is shown in both general arrangement and in much detail, and in every case with complete dimensions, the latter being entirely in millimeters. The notes accompanying the illustrations are printed in both English and German, and the plates, even without text, form a very valuable contribution as a ready means of reference to the best modern design.

Illustrating the scope of the work, it might be mentioned that machinery is illustrated from, among others, the following ships: *Spokane;* Holland-American, *Potsdam;* Hamburg-American, *Dortmund;* United States battleship, *Ohio;* the steamships *Sylvia, Asturia, Alaskan, Friedrich der Grosse, Neckar,* and *Victoria Luise.* As illustrating the completeness of presentation in these several cases it might be interesting to note the amount of detail in a single case.—that of the United States battleship *Ohio.* The plates for this ship cover eight of the sixty-four, and include the following: Longitudinal elevation and section of main engine; end view of same; sections and stud diagram of cylinder liners and covers; cross section of cylinder lay-out; longitudinal section of high pressure cylinder and valve chest with details, as well as the detail lay-outs of the other cylinders; high-pressure piston valve section, with a number of details of parts; the same amount of detail for the intermediate and low pressure cylinders, together with plans of cylinder covers and valve chests; sections and elevations of the slide valves for intermediate and low pressure cylinders; connecting rod drawings, including details and oiling system; piston rods; crossheads with details; crankshaft bearings; cylinder stuffing boxes; engine frame in much detail, and main bearings; three views of condenser, including section, besides a number of details; bilge and sanitary pumps in considerable detail. Some of the other cases include screw propellers, eccentrics, reversing and turning engines, and circulating pumps; and the examples are picked out so as purposely to include practice in compound, triple and quadruple expansion engines. In some cases independent machinery lay-outs are included, showing the relation of each part with regard to all the others, and giving not only cross sections of the ship, but longitudinal sections and plans of the engine room.

The importance of the work is very great and it should prove exceedingly valuable to designers of all sorts of marine machinery.

Steam Turbines. By Carl C. Thomas, Professor of Marine Engineering, Sibley College, Cornell University. Size 5¾ by 9 inches. Pages, 286. Figures, 92; plates, 17. New York, 1906. John Wiley & Son. Price $3.50.

The development of the steam turbine has been so rapid that many of the problems involved, while solved more or less satisfactorily for constructive purposes, have not been put upon a scientific basis. The velocity of steam flow under given conditions, which is important both for an understanding of the operation of the turbine and for predicting results to be obtained in any design, is one of the most important of these problems. The present work has consisted largely in an analysis and correlation of the results of important experimental investigations along this line, as well as on other points, and an attempt to use these results in connection with well known laws of hydraulics and thermodynamics, in the development of the theory and practice of the steam turbine. The book is expressly stated not to be a treatise on either hydraulics or thermodynamics, merely an outline of each being given in sufficient detail to use as a working basis.

The general subjects taken up under chapter headings include the action of steam upon turbine buckets; thermodynamics involved in the flow of steam; graphical representation of work done in heat transformations; calculation of the velocity and weight of flow; frictional resistances as affecting velocity; experimental work on the flow of steam through orifices, nozzles and turbine buckets. After this the turbine proper is discussed under headings of impulse turbines and impulse and reaction turbines; while another chapter is devoted to a description of the four turbines most prominent in practice in the United States—Westinghouse-Parsons, Curtis, Allis-Chalmers and De Laval. The last chapter is the one of most interest to our readers, as it deals with the marine steam turbine, and a considerable amount of data is given, thoroughly up to date, including particulars of installations as recent as those of 1905 in the *Carmania,* and other ships of that date. Illustrations in this section include three cuts showing the installation of the turbines on the *Carmania,* and three others giving curves of economy obtained on tests of various cruisers and torpedo-boat destroyers, as compared with similar vessels fitted with reciprocating engines.

Throughout the work the results of tests are given much prominence, and are, of course, invaluable, as showing what has been accomplished, and giving some means of predicting what may be obtained in future constructions. Illustrations are well chosen and well engraved, and the book as a whole forms a notable addition to the literature on this very lively topic.

Notes of Heating and Ventilation. By John R. Allen, A. S. M. E., Junior Professor of Mechanical Engineering, University of Michigan. Size 4½ by 6½ inches. Pages, 152; illustrations, 34; tables, 35. Chicago, 1905. Domestic Engineering. Price $2.00

This book is largely made up from the lectures delivered by the author to his classes on the subject, in the University of Michigan. It was written primarily for the steam fitter and the designer of heating systems, and presupposes a knowledge of the construction and operation of the simpler forms of such systems. It realizes at the outset that heating and ventilation have not yet become an exact science, but are dependent very largely upon questions to be settled by judgment and experience.

The introduction to the book takes up the general theory of heat and specific heat, and the work opens with a discussion of the loss of heat from buildings by transmission through walls and windows, by convection currents and by passage of air through the walls. The tables include the radiating and conducting power of various bodies; relative heat loss of different sorts of material, and the heating properties of same; sizes of flues for indirect radiation; computations for a specific case of a house of medium size for both direct and indirect systems of radiation; sizes of pipe and mains for heating; heat losses in ventilation, again taking up the specific case; capacities of fans under varying revolutions and other conditions; losses of pressure in pipes; relative values of different pipe coverings; and a number of other subjects connected with the general title. The different forms of heating are described and examples given, showing the processes by which the design of systems is brought about for both direct and indirect steam heating. The subject of ventilation is given very careful consideration in the last half of the work, and in both parts the illustrations are practical and well suited to the purpose in hand.

Link Motions, Valves and Valve Setting. By Fred H. Colvin. Size 4 by 6 inches. Pages 82; figures, 43 and one folding plate. New York, 1905. The Derry-Collard Co. Price 50 cents.

This little work covers the general subjects of locomotive link motion, valve movements, methods of setting the slide valve; analysis by diagrams of the slide valve and its operating mechanism; modern practice in length and angularity of eccentric rods, leads, lap, proportions of travel, piston speed, etc.; block slip; various forms of slide and piston valves, methods of setting piston valves and a short description of other forms of valve gears. The work appears to be thoroughly practical and the illustrations in particular are carried out with much care and are very clear. They are largely of the diagrammatic form so necessary to easy comprehension and clearness in design. Rules are given for determining variation of lead under various conditions, and examples are quoted giving the proportions in general of American valve motions for locomotives of different piston speeds and cylinder dimensions.

QUERIES AND ANSWERS.

All reasonable questions concerning marine engineering received from and signed by subscribers will be answered by the Editor in this column. All communications must bear the name and address of the writer.

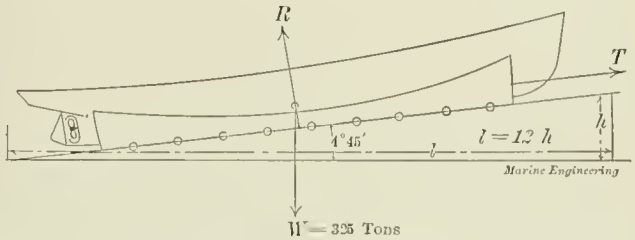
Q. 332.—Will you give a rule to find the number of tons of dead weight a boat will carry. The boat in question is built on the scow model. Her dimensions are as follows: length on deck, 125 feet; length on bottom, 100 feet; beam amidships on deck, 23 feet 9 inches; beam, forward 20 feet; beam, aft 21 feet; beam, amidships on bottom 22 feet 9 inches; beam, forward 19 feet; beam aft, 20 feet; depth of hold amidships from underside of deck to top of keelson, 5 feet; depth over all from top of deck to bottom, 6 feet 6 inches. J. E. B.

A.—There is no definite rule by which the dead weight carrying capacity of such a boat can be determined until we know the weight of the boat empty. In that case the capacity would be the difference between the displacement of the craft at the deepest draft to which it could be safely loaded, and the weight of the hull.

If the result were required from the point of view of knowing the draft of the boat light and the draft to which it was proposed to load it, the problem would be a very simple one. In this case, we would multiply the area of the load water plane by the difference in the drafts in feet, and dividing the result by 35 would obtain the dead weight carrying capacity in tons. The load water plane of such a vessel would be about equivalent to the product of the mean length of the vessel by the mean beam. In this case the mean length is 112½ feet, the mean beam about 21 feet, and the amount of dead weight carrying capacity for each foot of additional draft figures out as about 67.5 gross tons.

Q. 336—I am getting out a small marine railway and as I do not have much depth of water I am making it of a special design. I would like to know the method of estimating for the power required to haul this out, also the size of wire rope or chain necessary. If possible, please give me the coefficient of friction on rollers, and method of working it out to find force required to haul same out. Weight of vessel, 300 tons; weight of ways, 25 tons; inclination of ways, 1 in 12; to haul out in about one-half hour. J. R.

A.—The resolution of forces, as indicated in the accompanying diagram, shows a downward force due to the action of gravity of 325 tons, a force directed generally upward, due to the reaction of the rail upon the rollers and ways, of an amount to be determined later, a force acting longitudinally of the ways, and representing the tension in the cable used for drawing the ship out of



the water. This also will be determined later. The angle of inclination of the rails is such that the tangent is one-twelfth, which makes the angle 4° 45′. It results from this that the force acting upwards from the rollers is 325 sin 85° 15′ = 324 tons. The force longitudinally of the ways is 325 sin 4° 45′ = 26.9 tons.

The coefficient of friction in a case like this is not thoroughly well known, but may be assumed to be about equivalent to that given by rather poor results of railroad car wheels and axles. This would place it at about three percent, and would make the total friction of the rollers upon the rails 9.7 tons. This makes the force to be applied through the wire ropes used for hauling the ship out of the water 26.9 + 9.7 or 36.6 tons. It follows that a total force of about 37 tons will be required to give the ship a slow motion up the ways. It should be noted that this is a maximum, and a figure which is attained only after the ship is entirely out of the water. Before the ship leaves the water, the force required would be very much less, because much of the weight of the ship will be supported by the buoyancy of the water.

If we assume that a wire rope one inch in diameter is to be used, we find that the ultimate strength of such a rope is about 50,000 pounds. The use of six such ropes would so distribute the stress as to allow for a factor of safety of about 3.5, while eight ropes would increase this factor of safety to about 5, which ought to be ample. These ropes might be attached readily at two points, by using sheaves of considerable diameter (say 30 inches), and taking advantage of the fact that these sheaves might be so adjusted as to operate as pulleys, with four ropes at each point of attachment.

The time required to haul up the vessel is not directly dependent upon the force to be overcome, but is rather dependent upon the power utilized for the purpose. If the total distance through which the average resistance has to be met is 300 feet, and it is required to perform the operation in one-half hour, the average speed will be 10 feet per minute. This would require the application of about 25 horsepower to the ways, which would mean an engine of about 35 indicated horsepower, the difference being absorbed in engine friction and friction in the sheaves.

Personal.

Geo. H. Waring, Jr., late chief engineer in the steamship service of the Standard Oil Company, has joined the staff of the Union Foundry & Machine Works, Limited, St. John, New Brunswick, as outside manager.

In accordance with an act of congress, approved February 27, making the office of Engineer-in-Chief of the Revenue Cutter

Service a presidential appointment, the President on March 1 nominated the present incumbent, Chief Engineer Charles A. McAllister, for the post.

Obituary.

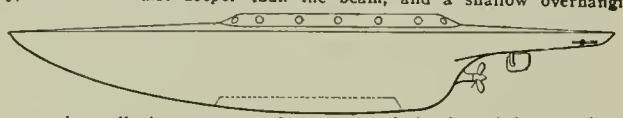
Frederick T. Towne, general superintendent of the Yale & Towne Manufacturing Company of Stamford, Conn., died suddenly on February 4 at the opening of a very brilliant business career. He was a graduate of the Massachusetts Institute of Technology, was in his thirty-fourth year, and was a son of the president of the company.

George V. Sloat, who resigned as superintending engineer of the Old Dominion Steamship Company six years ago, died February 14 at the age of seventy-nine. For a period of fifty years Mr. Sloat was identified with marine matters in various parts of the United States, the last thirty-five years having been in the service of the Old Dominion Company.

SELECTED MARINE PATENTS.

806,223. SUBMERGIBLE SURFACE BOAT. THOMAS H. WHELESS, NEW YORK, N. Y.

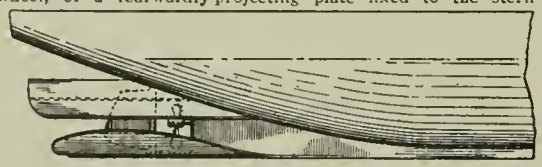
Claim.—4. A marine vessel adapted to run along the surface of the water or to be submerged when desired, comprising a sharp and narrow fore body, a narrow waist deeper than the beam, and a shallow overhanging



stern portion, all the contours of the hull of the boat being continuous curves, the lower portion of said waist being weighted, and the maximum width of each cross-section being at the deck-line, with a deck tapering slightly downward toward the bow and stern, and an elongated conning-tower mounted in the deck above the waist portion. Thirteen claims.

806,484. HULL OF VESSELS. ISAAC E. PALMER, MIDDLETOWN, CONN.

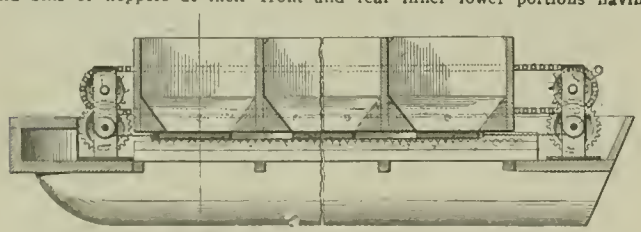
Claim.—3. The combination with the hull of a vessel provided with a power-wheel, of a rearwardly-projecting plate fixed to the stern portion



thereof and extending rearwardly above the wheel and laterally projecting wings on the keel below the said wheel arranged to co-act with the plate above the wheel to hold the water to the wheel. Four claims.

807,552. DUMPING-SCOW. JOHN GUIRY, NEW YORK, N. Y.

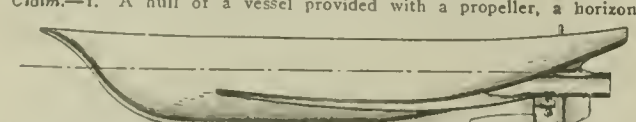
Abstract. The invention comprises two suitably-separated pontoons connected together by a deck, a longitudinal series of bins or hoppers arranged upon the scow and disposed between the vertical planes of the facing sides of said pontoons, a horizontally and longitudinally sliding gate for the bottoms of said bins or hoppers, and means for operating said gate, said bins or hoppers at their front and rear inner lower portions having



inclined or converging walls and said gate having a series of openings adapted at the proper time to register with the lower ends of said bins or hoppers, so as to permit the discharge of the refuse downwardly between said pontoons. The aforesaid sliding gate will when in one position close the lower ends of the bins or hoppers, so that the latter may be filled, and when moved from such position said gate will carry its discharge-openings below said bins or hoppers, and at such time the refuse may at once escape downwardly. Five claims.

807,769. HULL OF VESSELS. ISAAC E. PALMER, MIDDLETOWN, CONN.

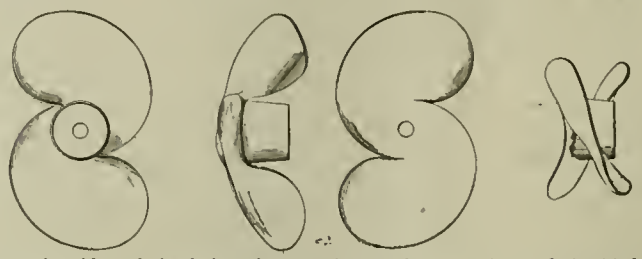
Claim.—1. A hull of a vessel provided with a propeller, a horizontal



wall extending rearwardly over the propeller, and bilge-keels merging into the opposite edges of said horizontal wall. Four claims.

807,974. PROPELLER. EDWARD A. STICKLER, PORTAGE, WIS.

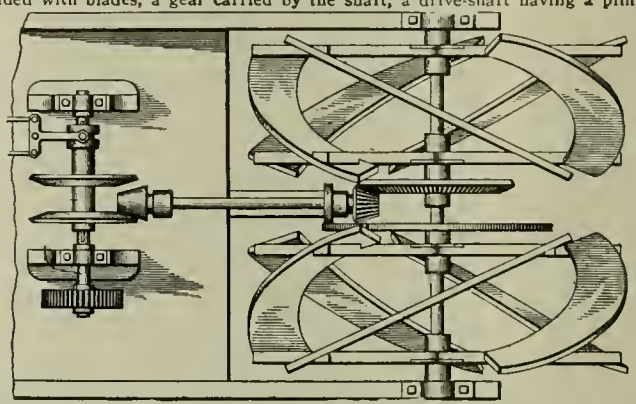
Claim.—1. A propeller having a hub and spiral cam-shaped blades, the front sides of which project from the front portion of the hub, said blades being curved rearwardly over the rear portion of the hub, widened progressively from the hub rearwardly and terminating in rearwardly-projecting wings, the rear edges of which present convex curves that extend from the outer edges of the blades inwardly, and the inner edges of which are spaced



from the sides of the hub and merge in the front portions of the blades attached to the hub. One claim.

808,034. PROPELLER. JOHN C. FRANKLIN, GALLATIN, TENN.

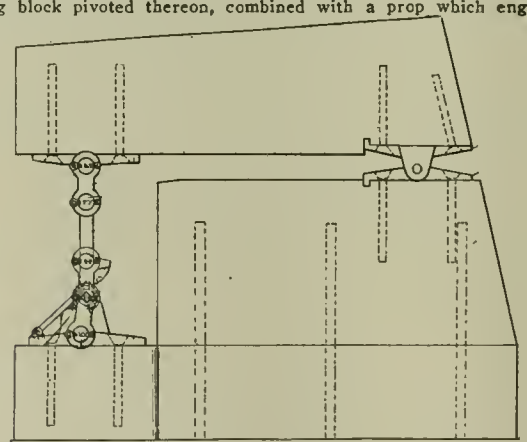
Claim.—1. In a device of the class described, a propeller-shaft provided with blades, a gear carried by the shaft, a drive-shaft having a pinion



in mesh with said gear, and co-operating bearing members fixed respectively on said shafts and acting to maintain the gear positively in mesh with pinion. Three claims.

808,072. BILGE-BLOCK FOR DRY-DOCKS. JAMES L. CRANDALL, MALDEN, MASS., ASSIGNOR TO H. I. CRANDALL & SON CO., BOSTON, MASS.

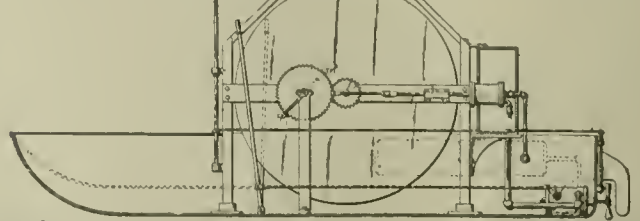
Abstract.—The invention consists, essentially, in a base-block and a bilge-engaging block pivoted thereon, combined with a prop which engages the



outer end of the bilge-engaging block and which when the bilge-engaging block is in its uppermost or normal position occupies a perpendicular position, but which is adapted to be moved downward and into an inclined position to drop the outer end of the bilge-engaging block, and means for moving said prop. Twenty-four claims.

808,346. BOAT-PROPELLING MECHANISM. PATRICK E. CROWE, NEWARK, N. J.

Abstract. This invention relates to a novel means of propulsion for boats, comprising an air-engine driven from compressed air, an arrangement of air receiver or receivers into which the air is to be delivered and com-



pressed, the compressed air being conducted from said receiver or receivers, preferably two of them, to the air-engine, which is provided with a pair of turbines or wheels running independently of each other in opposite directions, for the forward or backward propulsion of the boat, as may be desired, an independently-arranged and independently-acting and preferably manually-actuated pump-operating mechanism and pump or pumps for forcing air into said receiver or receivers. Seventeen claims.

International Marine Engineering

MAY, 1906

CONTRACT TRIAL PERFORMANCE OF THE UNITED STATES BATTLESHIP LOUISIANA.

BY A. F. BOWEN AND H. B. GREGORY.

GENERAL DESCRIPTION.

The armored battleship *Louisiana* is of the *Connecticut* class. The bill for this class as passed by congress stated that one ship should be built in a private yard and one in a government yard. The contract for building the *Louisiana* was awarded to the Newport News Shipbuilding and Dry Dock Company, they being the lowest bidders, while the New York navy yard was designated by the government as builders of the *Connecticut*. The successful bidders signed the contract October 15, 1902, laid the keel February 7, 1903, and launched the ship August 27, 1904.

HULL DIMENSIONS.

Length between perpendiculars (also L. W. L.)	450 ft.	0 in.
Length over all	456 ft.	4 in.
Projection of ram forward of F.P.	6 ft.	4 in.
Breadth molded	76 ft.	5½ in.
" extreme	76 ft.	10 in.
Ratio length to beam		5.856
Depth molded to main deck side at midship section	43 ft.	1⅜ in.
Draft	24 ft.	6 in.

THE BATTLESHIP LOUISIANA ON TRIAL TRIP.
(Copyright, 1905, by N. L. Stebbins, Boston)

The contract price of the *Louisiana* was $3,990,000. There was apportioned to hull (not including armor, ordnance, anchors, etc.) the sum of $2,990,000, and to machinery $1,000,000. The contract time for completion was 41 months, thus making the date March 15, 1906. The speed to be developed was 18 knots for four consecutive hours on a mean draft of 24 feet 6 inches, the maximum air pressure finally allowed being 2¼ inches and the average air pressure not to exceed 2 inches.

The complement is as follows:

Admiral	1	Seamen branch	401
Chief of staff	1	Artificer "	45
Commanding officer	1	Engine room branch	226
Wardroom officers	19	Special "	33
Junior "	20	Messmen "	27
Warrant "	9	Commissary "	17
Officers	51	Marines	72
		Additional for Flag	19
Men	840		840
Total	891		

Displacement, normal—24-foot 6-inch draft	15,970 tons
" per inch—" " " " "	63.2 tons
Area of immersed midship section	1,808 sq. ft.
Area of load water plane	26,560 sq. ft.
Area wetted surface at normal draft	44,500 sq. ft.
Center of gravity of L. W. L. plane aft of M. S.	4.4 ft.
Center of buoyancy above bottom of keel	13 ft. 4 in.
" " " aft of M. S.	0.765 ft.
Transverse metacenter above center of buoyancy	18 ft. 9½ in.
Longitudinal " " " " "	538 ft. 6 in.
Coefficient of fineness—block	0.6592
" " " —midship section	0.9604
" " " —L. W. L. plane	0.7683
" " " —cylindrical	0.6963
Number of frames (spaced 4 feet throughout)	112
" " " watertight compartments	314

THE UPPER DECK.

The upper deck extends between the two 12-inch turrets, and forms the upper part of the superstructure. Over the forward

end is built the bridge deck, having thereon the chart room and the captain's emergency cabin, and above this is the flying bridge. Over the after end is the signal bridge, at the level of the top of the signal tower.

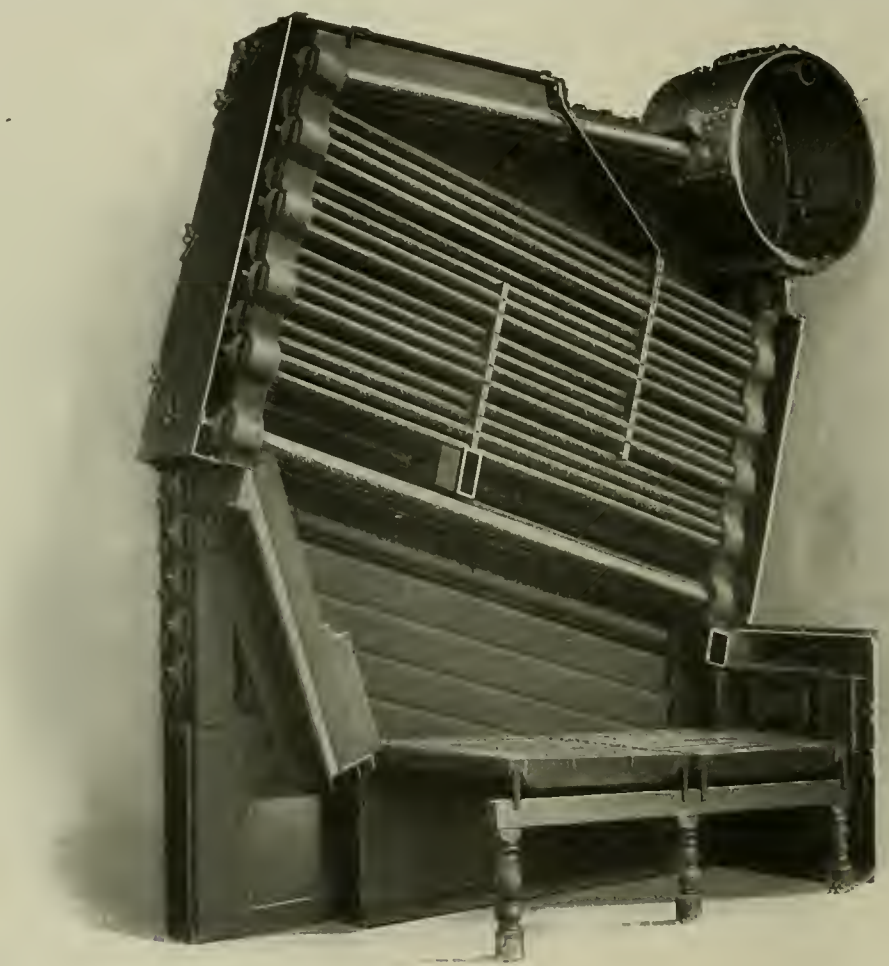
The following boats are carried on the upper deck: one 50-foot steam cutter (a 40-foot steam cutter is temporarily fitted); two 36-foot steam cutters; one 36-foot launch; three 33-foot launches; five 30-foot cutters; one 30-foot barge; two 30-foot whaleboats; one 30-foot whaleboat gig; two 20-foot dinghies; one 16-foot dinghy; one 14-foot dinghy.

THE MAIN DECK.

This deck extends from the stem to the stern, and is covered in part by the upper deck extending between the two turrets. The bandroom, isolation ward, sick bay and lavatory, operating room, dispensary, refrigerating plant, laundry, machinists' and petty officers' quarters; while the after part contains the wardroom, junior and warrant officers' staterooms, and dining rooms.

ARMOR.

There is fitted a complete water-line belt 9 feet 3 inches wide amidships, stepped down at the ends. In wake of the machinery spaces the armor will be 11 inches at the top, tapering to 9 inches at the bottom. Forward and aft the armor will step down to 9 inches at the top and 7 inches at the bottom, then to 7 inches at top and 5 inches at bottom, then to 5 inches constant thickness, and then to 4 inches constant thickness.



SECTION THROUGH ONE OF THE BOILERS, SHOWING HEADERS AND BAFFLES.

two 12-inch turrets with four 12-inch guns, and the four 8-inch turrets with eight 8-inch guns are mounted on this deck. The six 3-inch guns are covered by the upper deck.

In the forward part of the superstructure is located the crew's galley, and about amidships the officers' galley; while just forward of the machinery hatch are the executive and paymaster's offices.

THE GUN DECK.

Forward on this deck are the crew's showers, lavatories and the windlass engine. Then comes the casemate containing the twelve 7-inch guns in separate armored compartments. Abaft the casemate are located the quarters for the admiral, captain, chief of staff, and wardroom officers.

THE BERTH DECK.

The forward part of the berth deck contains the paints and oils,

Above the belt armor are the lower casemate of 6 inches and the upper casemate 7 inches thick, respectively. There are two 12-inch elliptical balanced turrets, forward and aft, respectively, revolving over circular barbettes. The turret armor is 12 inches thick on the port plates, and 8 inches thick on the sides and back. There are also four 8-inch elliptical broadside turrets, the port plates of which are 6½ inches thick, while the back and sides are 6 inches.

ORDNANCE.

Main battery: four 12-inch breech-loading rifles; eight 8-inch breech-loading rifles; twelve 7-inch rapid-fire rifles.

Secondary battery: twenty 3-inch 50-caliber rapid-fire rifles; ten 3-pounder semi-automatic Hotchkiss rapid-fire rifles; two 1-pounder automatic guns; two .30-calibre machine guns.

The ship has also four 21-inch submerged torpedo tubes, two forward and two aft, with the necessary compressors, accumulators, separators, etc.

EQUIPMENT.

Electric Plant.—There are eight 100-kilowatt generating sets furnished by the General Electric Company, four of which are located in the forward dynamo room, and four in the after dynamo room. The lighting installation consists in general of about 1,100 incandescent 16-candlepower lamps; 1,758 incandescent 5-candlepower lamps for use in the battery control instruments; one arc lamp in each of the fire rooms, and two in each of the engine rooms, making a total of ten arc lamps. The eight vertical cross compound, 100-kilowatt dynamo engines have cylinders 10 and 18 inches in diameter with the common stroke of 10 inches.

The same company also furnished the searchlights, of which there are four 30-inch and two 60-inch, controlled by hand, and two sets of night signalling apparatus; besides various other electrical machinery.

Anchor Windlass.—The steam windlass is of the vertical Hyde type, located on the main deck forward, while the engine is outside of the windlass house, and placed on the gun deck.

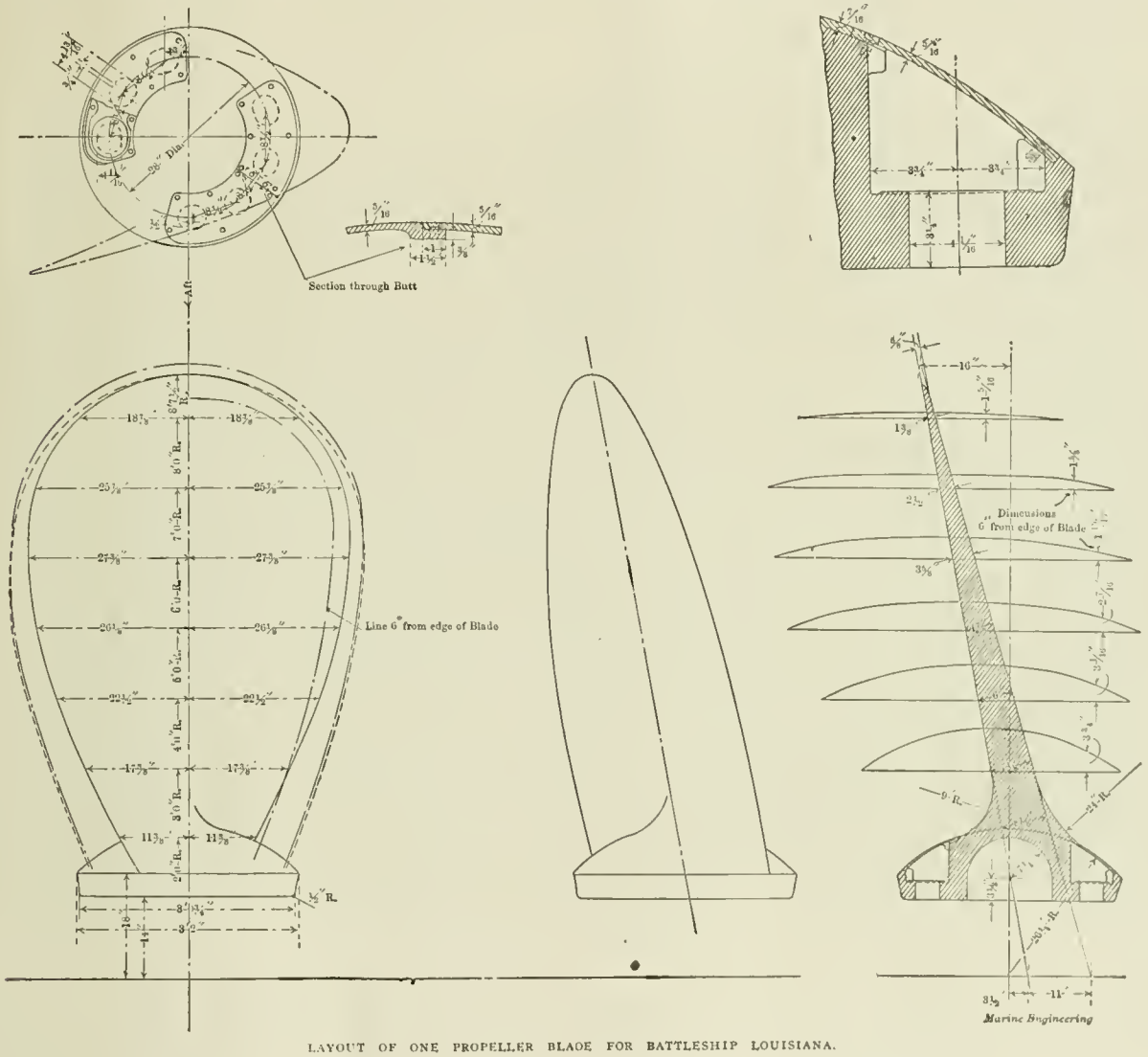
Winches.—All told there are six electrically driven deck winches, four of which are on the main deck forward and aft, the other two being situated on the upper deck.

Steering Engine.—In the steering room there is a combined hand and steam steering engine of the Williamson Brothers type, double cylinders, 15 inches diameter by 12 inches stroke. The engine is controlled from the flying bridge, conning tower, and communicating room, by wire rope actuating the engine valve.

Ventilation System.—The ventilation is accomplished by means of sixteen sets, the greater number being on the plenum system, and supplying air to the several compartments. About 90,600 cubic feet of air is supplied per minute, and 13,846 cubic feet exhausted.

PROPELLING MACHINERY.

The main engines, two in number, are of the four-cylinder, vertical, inverted, direct-acting, triple expansion type, placed abreast in two separate watertight compartments with communicating watertight door at the working platform. The order of the cylinders, beginning forward, is: forward L. P., H. P., I. P., and after L. P. The crank sequence is: H. P., I. P., F. L. P., and A. L. P., all crank angles being ninety degrees. The engines are right and left, and turn the propellers inboard when going ahead. The designed indicated horsepower of the main engines was 16,500 at about 120 revolutions per minute, with a steam pressure of 250 pounds at the high-pressure steam chest.

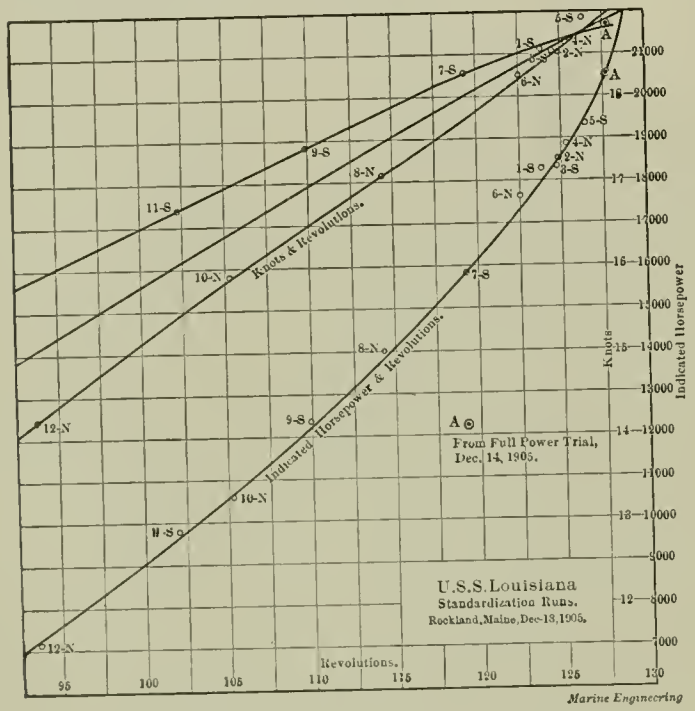


LAYOUT OF ONE PROPELLER BLADE FOR BATTLESHIP LOUISIANA.

The main engine cylinder casings are of cast iron, and are fitted with cast iron liners in the barrels and valve chests. The cylinder liners make steam tight joints with the casings both at the top and the bottom, and the space between the liner and the casing forms the steam jacket for the cylinder barrel. All cylinder covers, except the H. P., are also jacketed.

The framing of the main engines is in accordance with general naval practice, consisting of forged steel cylindrical columns,

twelve in number, supporting the cylinder, crosshead guides, etc. They are flanged top and bottom for securing to the cylinders and the bedplates, and have enlarged facings for the athwartship and longitudinal tie rods, braces, and reversing shaft bearings. The columns are tied fore and aft by heavy cast steel horizontal I braces and forged steel horizontal and diagonal rods, and strengthened athwartship by forged steel X frames, extending from top to bottom of columns, and horizontal tie rods at the center of the columns and X frames. Additional stiffness is afforded the engines by fore-and-aft and athwartship tie rods, between the cylinders of opposite engines, and between the forward and after engine room bulkheads and the engine cylinders.



CURVES REPRESENTING RESULTS OF STANDARDIZATION RUNS.

Heavy cast steel bed plates, consisting of longitudinal and cross I girders, secured to strong foundations built in the hull structure, provide a solid base for the engines. Each bed plate is in three sections securely bolted together. Two main bearings, consisting of bottom brass and cast steel cap, both lined with white metal, are carried in each section.

The main valves are of single ported piston type. They are built up with top and bottom cast steel heads, and a steel tube distance piece between the heads. Each head is fitted with a single cast iron packing ring and cast steel follower. The H. P. cylinders have one valve, and the I. P. and L. P. cylinders two valves each. A balance piston, fitted at the top of each valve stem and working in a small cylinder in the top valve chest cover, is provided to relieve a part of the weight of the valve gear.

The latter is of the double bar Stephenson link and sliding block type. The H. P. valve stem connects direct to its link block, while the two valve stems of each I. P. and L. P. cylinder are secured to a crosshead, which in turn is connected to the link block.

Each main engine is handled by a vertical steam reversing engine with oil controlling cylinder, secured to the H. P. cylinder casing. A reversing shaft is carried in bearing brackets secured to the front of the engine columns and provided with an arm, for each link, fitted with adjustable cut-off block, and two arms for the reversing engine connecting rods. The reversing engine is controlled by a lever at the working platform.

An 11-inch balance throttle valve is provided for each engine. The valve is operated by a large handwheel at the working platform.

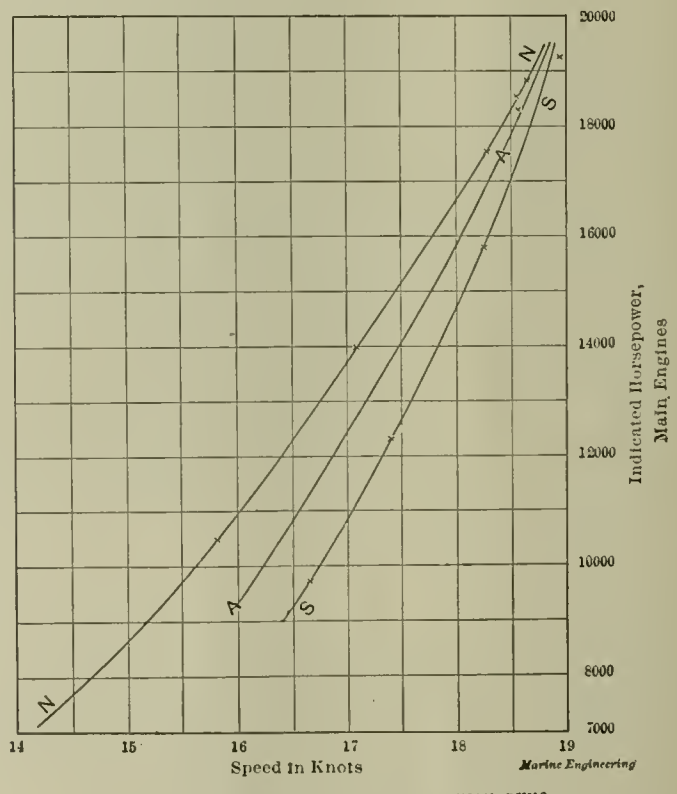
The pistons are of the ordinary cone shape, the H. P. being of cast iron and the I. P. and L. P. of cast steel. All pistons are fitted with forged steel followers secured to the piston bodies by studs having square shoulders, to prevent turning, where they pass through the followers. The H. P. and I. P. pistons are each fitted with one solid packing ring, set out by 18 and 27 steel springs respectively. The L. P. piston packing rings are in two rings of six sections each, set out by 32 steel springs.

The piston rods are of nickel-steel, oil tempered and annealed, and bored axially. They are ground cylindrically true, and polished. Each end is tapered, the upper for the reception of the piston and the lower for the crosshead. The crossheads are also of nickel-steel, and carry a cast steel slipper, which is lined with white metal on the sliding faces.

The go-ahead crosshead guides are of cast iron, hollow for water circulation, and are bolted to the top and bottom horizontal fore-and-aft I braces of the engine framing, and also hung from the cylinder bottoms by small column hangers. The backing guides are of cast steel, and are bolted to facings on the go-ahead guides.

The connecting rods are of the same material as the piston rods, and have axial holes. They are forked at the upper end to carry the crosshead brasses, and the lower end is faced to receive the crank pin brasses. All the brasses are secured by a forged steel cap and bolts.

All the eccentrics are in two parts, which are bolted together and keyed to raised seatings on the crank shafts. The go-ahead eccentrics are arranged for slight adjustment, by means of a slot



SPEED-POWER CURVES FROM STANDARDIZATION RUNS.

of greater width than the key, which permits their being shifted radially. The space between the sides of the key and slot is fitted with filling pieces, to prevent the eccentrics from slipping.

The eccentric straps are of composition, lined with white metal. They are in halves, fitted with distance pieces and bolted together. To the upper part of the straps are secured the eccentric rods, which are of nickel-steel. The upper ends of the rods are forked to span the main links at the link pins, adjustable brasses being fitted for these pins.

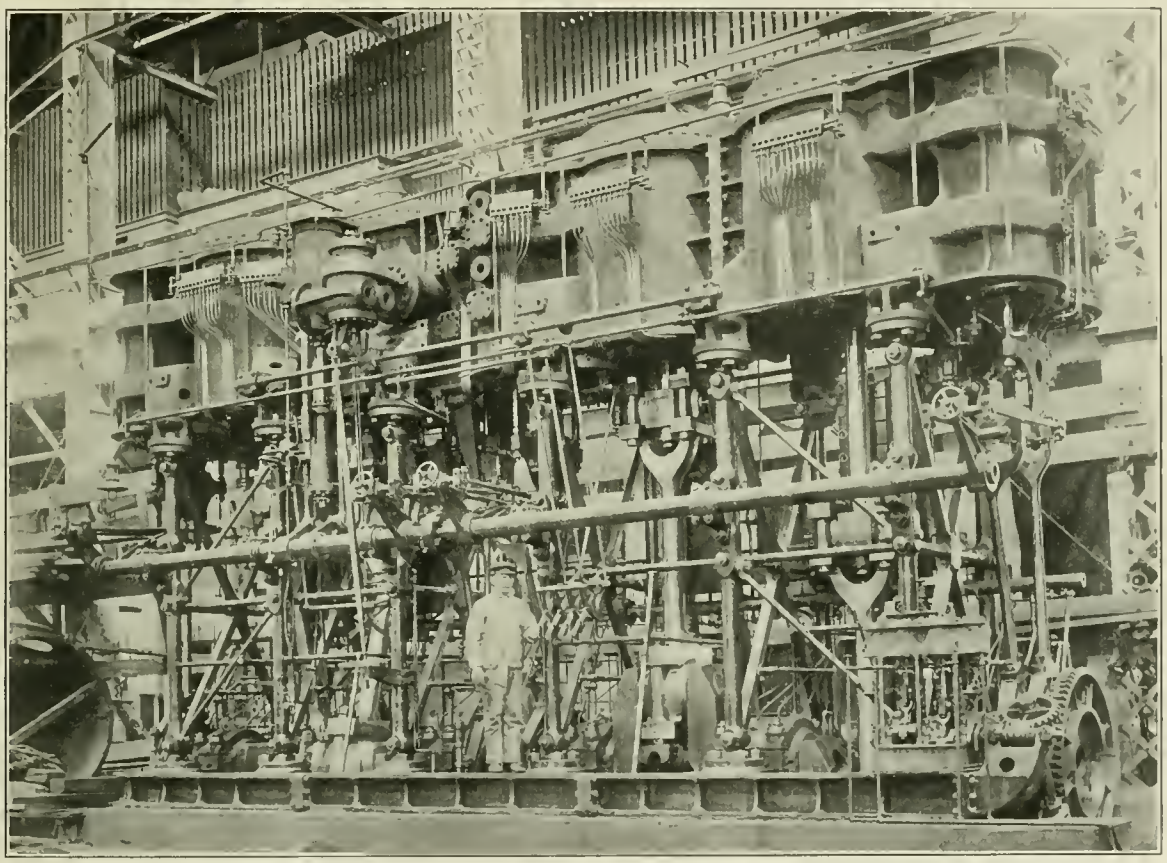
Each main engine has six sections of shafting, as follows:—two sections of crank shaft, and one each of thrust, line, stern tube, and propeller shafts. All shafting is hollow forged nickel-steel. The stern tube shafts, which cannot be readily examined, are protected against the corrosive action of the sea water by a brass casing, shrunk on. Paint alone protects the propeller shafts against this corrosion, as they are easily accessible for examination, cleaning, and repainting, whenever the vessel is docked. Both the stern tube and propeller shafts are fitted with heavy brass journals at the stern tube and strut bearings.

All shaft couplings are of the standard flange type, forged to the shafts, except the forward coupling of the stern tube shaft, and the outboard coupling connecting the stern tube and propeller shafts. The former consists of a forged steel collar secured to a raised seating on the shaft by four keys. Behind this collar is a ring in halves, which fits around the shaft and against the shoulder of the collar seating, both collar and ring being through bolted to the after coupling of the line shaft. The outboard coupling consists of a forged steel sleeve, taper bored from each end to center, for receiving the tapered shaft end. The sleeve is secured to the shaft ends by four keys and two cotters. The sleeve couplings are covered by a watertight cast composition casing, the space between the casing and coupling being filled with tallow and rosin melted together.

There are six main bearings for each complete crank shaft, consisting of hollow cap and brass for water circulation, and lined with white metal. Two steady bearings are provided for each thrust shaft, and two spring bearings for each line shaft. Each end of the stern tubes is fitted with a lignum vitae lined bearing for the stern tube shafts, and both struts are provided with a similar bearing for the propeller shaft. A stuffing box and gland, for preserving watertightness, are fitted at the forward end of each stern tube, in the shaft alley. Wherever the shafting pierces a watertight bulkhead a shallow stuffing box is fitted around it.

There is one thrust bearing for each main engine, of the ordinary horse shoe type. It consists of a cast iron pedestal bolted to a cast iron sole plate, which is securely riveted to the foundation built in the hull structure. The lower part of the pedestal forms an oil trough in which the lower part of the thrust collars turn, the trough being fitted with a water circulating coil for cooling the oil. A steady bearing is at either end of the pedestal. There are thirteen horse shoes of cast steel, made hollow for the circulation of cooling water, and lined with white metal on the bearing surfaces. Each horse shoe is independently adjusted fore-and-aft by screwed steel side rods and clamp nuts.

The turning gear, for each engine, consists of a double engine, which drives by worm gearing a large worm wheel keyed to the after crank shaft coupling. There is also a ratchet attachment for turning by hand.



STARBOARD ENGINE OF BATTLESHIP LOUISIANA, ERECTED IN SHOP.

An efficient water service fitted to the engines, and supplied from the sea by the main circulating pumps, has branches leading to the different parts of the engines and the bearings in the shaft alleys. Located high in each engine hatch is an oil tank for supplying lubricating oil to the main engines. Each tank has a gravity supply pipe leading to the distributing oil boxes on its engine, where the flow of oil to the different working parts of the engine is controlled.

MAIN ENGINE DATA.

Cylinders, H. P., diameter, inches	32½
I. P., " "	53
L. P. (2), " "	61
Stroke of all pistons, inches	48
Piston valves, H. P. (1 each cylinder) diameter, inches	17½
I. P. (2 " ") " "	19
L. P. (2 " ") " "	19
Main steam pipe, diameter at throttle, "	11
Net area of I. P. to H. P. piston, ratio	2.659 to 1
L. P. pistons (2) to H. P. piston, ratio	7.046 to 1

Piston rods, diameter, inches	7¼
axial hole, H. P., inches	1½
I. P., "	3
L.P., "	4⅜
length, feet and inches	9-0
Connecting rods, length center to center, inches	96
diameter, upper end, "	6⅞
lower " "	8
axial hole, H. P., "	1½
I. P., "	3⅜
L. P., "	4⅞
Crank shaft, diameter, inches	16½
axial hole, inches	9½
coupling disc, inches	29½
thickness coupling disc, inches	3¼
coupling bolts (8-each flange), diameter inches	3¼
length forward section, H. P. and F. L. P., feet and inches	14-7½
length after section, I. P. and A. L. P., feet and inches	16-4½
Crank pin, diameter, inches	17½
length, inches	19
axial hole, diameter, inches	10
Crank webs, width, inches	19
thickness, inches	10¼
Thrust shafts, diameter, inches	15½
axial hole, diameter, inches	9½
collars, number each draft	13
length, feet and inches	16-7
diameter, inches	24¼
thickness, inches	2
space between, inches	4
Line shafts, diameter, inches	15½
" axial hole, inches	9½
length, feet and inches	27-0
Stern tube shafts, diameter, inches	16½
" axial hole, inches	9½
length, feet and inches	37-9
Propeller shafts, diameter, inches	16½
" axial hole, inches	9½
length feet and inches	28-5½
Reversing engines, diameter steam cylinder, inches	15
" oil cylinder, inches	7½
stroke, inches	20
Turning engines, diameter steam cylinders (2), inches	7
stroke, inches	5

AUXILIARY MACHINERY.

Main Condensers.—There is one main condenser in each engine room. They are of the horizontal, cylindrical, surface condensing type, with steel shells and composition water heads.

Diameter of shell, inside	6 feet 7 inches
Length over all	15 " 4½ "
Tubes, diameter, outside	⅝ "
thickness, No. 18 B. W. G.	0.049 "
length between tube sheets	13 feet 0 "
number in each condenser	4,878
Cooling surface, square feet, each	10,375

Main Air Pumps.—A main air pump is provided for each main condenser. They are of the Blake, twin-cylinder, vertical, beam, single acting type.

Diameter of steam cylinders (two)	12 inches
" " pump " (two)	30 "
Stroke	18 "

Main Circulating Pumps.— One centrifugal, double-inlet, circulating pump, driven by a compound engine, is furnished for each main condenser. Each pump has a capacity of 12,000 gallons of water per minute at about 265 revolutions. The pumps are arranged to draw from the sea, the main drain, and from the engine room bilge; and discharge through the condenser or directly overboard, through the by-pass in the inlet and outlet condenser head, to the overboard delivery. The suction valves of these pumps are so interlocked that the sea valve and the bilge or drain valves cannot be opened at the same time.

Diameter of steam cylinders	H. P. 11 inches, L. P. 22 inches
Stroke	10 inches
Diameter of pump runner	45 inches
inlet nozzle	18½ inches
outlet nozzle	21 inches

Feed and Filter Tanks.—There is located in each engine room, one combined feed and filter tank, of 5,525 gallons capacity. The filter box is built in the forward upper end of the tank. It consists of three separate compartments, each filled with the filtering material, through which the water from the main and auxiliary air pumps' discharge passes successively before entering the feed tank.

Feed Pumps.—There are four main feed pumps, of the Blake, simplex, vertical double acting, center packed plunger type, two in each engine room. They are arranged to draw water from the feed and filter tanks, and discharge to the main feed line direct or through the feed water heater, and then into the main feed line.

Six auxiliary feed pumps, of the same type as the above, are located one in each fire room. They have suctions from the feed and filter tanks, the sea, the boiler blowpipes, and the drainage manifolds in their own compartment, and discharge into the auxiliary feed line, overboard and into the fire main.

	Main Feed Pumps	Aux. Feed Pumps
Diameter of steam cylinder	13 inches	11 inches
water cylinder	9½ inches	8 inches
Stroke	12 inches	12 inches

Hotwell Pumps.—In each engine room there is one Blake, simplex, vertical, double acting, hotwell pump, having suction connections from the bottom of the main condensers, the reserve feed tanks in the double bottoms, and the filling pipes from the ship's side. These pumps discharge into the feed and filter tanks and into the reserve feed tanks.

Diameter of steam cylinder	12 inches
water cylinder	14 inches
Stroke	12 inches

Distiller Circulating Pump.—There is one distiller circulating pump in the starboard engine room, of the same size and type as the hotwell pumps. This pump has a sea suction and discharges through the distillers and overboard, or into the flushing main.

Fire and Bilge Pumps.—One fire and bilge pump of the Blake, simplex, vertical, double acting type, is located in each engine room. These pumps draw water from the sea, the drainage system, and from the bilges in their own compartment, and discharge into the fire main or overboard.

Diameter of steam cylinder	12 inches
water cylinder	10 inches
Stroke	12 inches

Feed Water Heaters.—A vertical cylindrical feed water heater is located in each engine room, on the discharge side of the main feed pumps. The heating agency is exhaust steam from the auxiliary exhaust line, which enters the shell at the top, circulates around the tubes, and drains at the bottom to the main or auxiliary condensers. The feed water passes through the tubes, from bottom to top. A slight back pressure is kept in the auxiliary exhaust lines, for properly heating the feed water, by adjustable spring relief valves at the connections to the condensers.

Diameter of shell, inside	2 feet 5½ inches
Length over all	10 feet 4 inches

Tubes, number in one heater..... 683
diameter, outside..... ⅝ inch
thickness, No. 16 B. W. G..... 0.065 inch
length between tube sheets.... 7 feet 5 inches
Heating surface, each heater, square feet..... 829

Auxiliary Condensers.—There are four auxiliary condensers, one in each engine room, and one for each dynamo room. They are of the Wheeler surface condensing type, with combined air and circulating pump, of the Blake horizontal, simplex type, attached to and under the condenser.

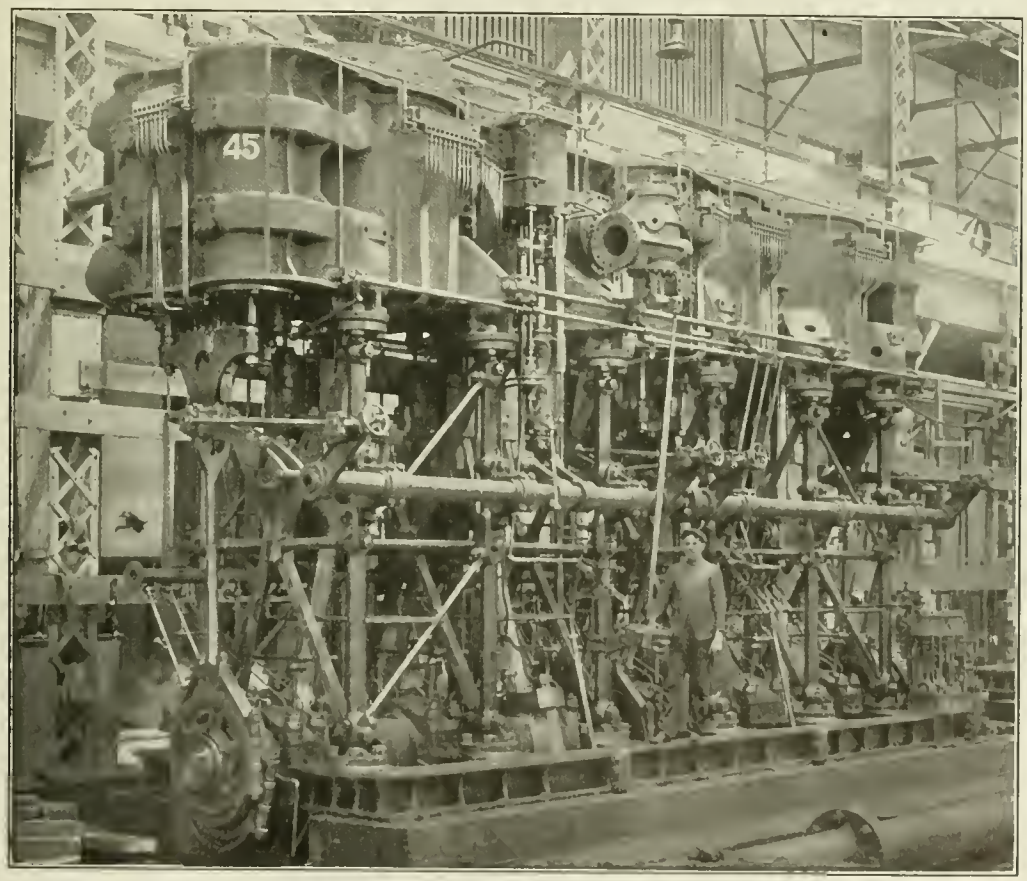
	Engine Room	Dynamo Room
Diameter of shell, inside	2 feet 4 inches	2 feet 7½ inches
Length over all	7 feet 0 inches	8 feet 11¾ inches
Tubes, number, each	518	781
diameter, outside,	⅝ inch	⅝ inch
thickness No. 18 B. W. G.	0.049 inch	0.049 inch
length between tube sheets	6 feet 6 inches	7 feet 7⅛ inches
Cooling surface, square feet, each	551	970

Steam cylinders, diameter..... 6 inches
Stroke ..... 5 inches
Fan, diameter ..... 66 inches

Ash Hoists.—For the removal of ashes, the ventilator in each fire room is fitted with angle guide strips to facilitate the hoisting of the ash buckets through same, and thence by trolley to the chutes at the ship's side. The hoisting is done by three Williamson Brothers 4½ by 4½ inches reversible ash hoist engines, one located just below the upper deck level immediately above each pair of athwartship fire rooms.

Distilling Apparatus.—The distilling apparatus is on the berth deck just forward of the engine hatches. It consists of three evaporators, of the horizontal straight tube type, two vertical distillers, located in a trunk above the evaporators, and the necessary accessories. The designed capacity of the plant was 16,500 gallons of water per twenty-four hours, which requirement was most successfully met when tested.

	Evaporators	Distillers
Diameter of shell, internal	5 feet 0 inches	18½ inches
Length over all	6 feet 9½ inches	6 feet 11 inches
Tubes, number, each	96	187



STARBOARD ENGINE OF BATTLESHIP LOUISIANA, LOOKING AFT.

Auxiliary Air and Circuloting Pumps.—

	Engine Room	Dynamo Room
Diameter of steam cylinder	6 inches	10 inches
air cylinder	10 inches	14 inches
water cylinder	10 inches	16 inches
Stroke	12 inches	12 inches

Forced Draft Blowers.—Twelve Sturtevant blowers, located two in each boiler compartment above the boilers, supply the forced draft. The blowers deliver directly into the fire rooms, the closed fire room system being used. The engines are two cylinder, upright and double.

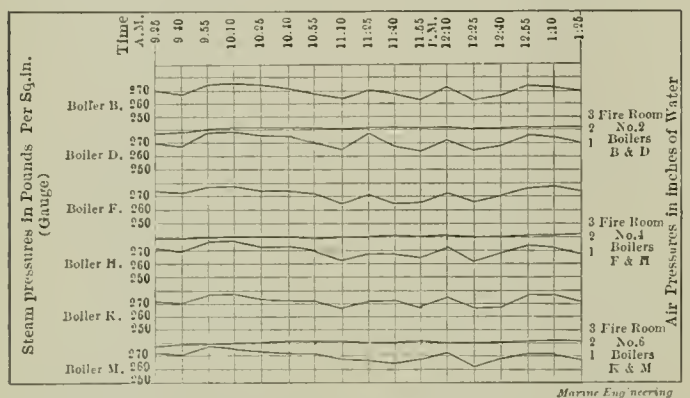
diameter, inside	2 inches	⅝ inch
thickness, No. 12 and 16 B. W. G.	0.109 inch	0.065 inch
length between tube sheets	5 feet 5⅛ inches	5 feet 5 inches
Heating surface square feet, tubes	275	165
Capacity each, gallons per 24 hours	5,500	8,250

Refrigerating Apparatus.—This plant consists of two 2-ton horizontal Allen dense air ice machines of the latest design and

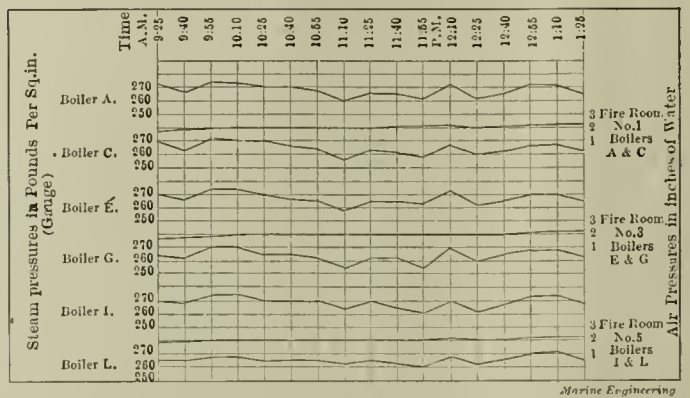
naval practice, supplying cold air to the cold storage rooms, ice making tank, and the scuttle butts. The official test of this plant showed highly satisfactory results.

General Workshop.—Located on the berth deck, between the engine hatches, is the general workshop. All the tools have independent electric driving motors. The following tools are installed: One 36-inch and one 14-inch lathe; one milling machine; one shaper; one 22½-inch drill press; one 12-inch sensitive drill; one double-wheel emery grinder; and bench vises.

An air compressor is installed in the port engine room for running pneumatic tools.


Time
Steam pressures in Pounds Per Sq.in. (Gauge)
Air Pressures in Inches of Water
Boiler B.
Boiler D.
Boiler F.
Boiler H.
Boiler K.
Boiler M.
3 Fire Room 2 No.2 Boilers B & D
3 Fire Room 2 No.4 Boilers F & H
3 Fire Room 2 No.6 Boilers K & M
Marine Engineering

STEAM AND AIR PRESSURES IN PORT FIREROOMS, FOUR-HOUR TRIAL.


Time
Steam pressures in Pounds Per Sq.in. (Gauge)
Air Pressures in Inches of Water
Boiler A.
Boiler C.
Boiler E.
Boiler G.
Boiler I.
Boiler L.
3 Fire Room 2 No.1 Boilers A & C
3 Fire Room 2 No.3 Boilers E & G
3 Fire Room 2 No.5 Boilers I & L
Marine Engineering

STEAM AND AIR PRESSURES IN STARBOARD FIRE ROOMS, FOUR-HOUR TRIAL.

SCREW PROPELLERS.

The two propellers are of manganese bronze and turn inboard when going ahead. They have three blades, and are designed as true screws. The surfaces of the blades are ground smooth with an emery wheel and edges filed sharp. The hub and blades are cast separate, the latter being bolted to the hubs by seven tap bolts each. The bolt holes in the palm of the blades are elliptical to permit of adjusting the pitch. After the pitch has been set the blades are secured against turning, by composition chock pieces fitted in the space between the bolts and the edges of the elliptical holes. The design of the blades is shown in the drawing on page 167.

Diameter of propeller	17 feet 3 inches
hub	4 feet 4½ inches
Pitch, as set	18 feet 0 inches
" ratio to diameter	1.0435
" variable between	17 feet and 19 feet
Helicoidal (developed) area, square feet	84.5
Projected area, square feet	71.5
Disk area, square feet	233.71

BOILERS.

Steam is supplied by twelve Babcock and Wilcox water tube boilers of the latest design, arranged, two each, in six comunicating watertight compartments, with athwartship fire room between each two boilers. Each boiler has a horizontal drum across the front at the top. Below the drum and connected to it are the front headers, placed side by side across the front of the boiler, and inclined slightly forward to give the tubes the necessary angle of inclination for proper water circulation. The tubes connect to the front headers, and extend back over the grates to join the rear headers, the latter connecting with the drum through circulating tubes at the top of the boiler. At the sides of the furnaces and in the center, dividing the two, are square water boxes, connected front and back to vertical boxes, which join with the tube sections above. Efficient lagging is provided and the casing is of light sheet steel. Doors are fitted in the side casings to permit cleaning the tubes. All the headers are provided with handholes opposite each tube, or group of tubes, for removing and renewing same. The baffling is so arranged that the gases of combustion have to cross the tubes three times before exit to the uptake. The arrangement of the tube sections and drums, and the method of baffling, are clearly shown in the illustration on page 166.

There are three smoke pipes, 8 feet 3 inches internal diameter, by 92 feet 5 inches high above the grates. Four boilers connect to each smoke pipe.

Floor space, length, each boiler	10 feet 1 inch
width	14 feet 10½ inches
Number of furnaces	two
Grates, length	7 feet 0 inches
width	6 feet 6⅜ inches
surface, square feet	91.42
" all boilers, square feet	1,097
Heating surface, square feet	4,396
all boilers, square feet	52,752
Heating surface÷Grate surface	48.09
Cross section smoke pipe÷Grate surface	0.146
Number of tube sections in each boiler	25
Tubes, diameter	2-inch 4-inch
number	786 53
thickness, B. W. G. and inches	No. 8=0.165 No. 6=0.203
Diameter of steam drum	42 inches
Length of steam drum, external	15 feet 3⅛ inches
Thickness of steam drum	$\frac{2}{3}\frac{1}{2}$ inch
Working pressure, designed, pounds per square inch	265

STEAM AND EXHAUST PIPES.

The main steam pipes, of seamless drawn steel, are arranged in two symmetrical systems, one on each side of the center line bulkhead. Each system is independent, except for an 8-inch cross-connection in the engine rooms. Steam is taken directly from the auxiliary steam pipes, through 7-inch branches, and so indirectly from the boilers. These branches from the forward and middle compartments unite in one 9-inch pipe, which is increased to 11 inches where joined by the branches in the after boiler compartment, and this diameter is continued to the engine. A separator is fitted in each system near the engine.

The auxiliary steam pipes take steam directly from the boiler through 5-inch pipe connections, and extend throughout the machinery space, with branches to the main steam pipes, as stated in preceding paragraph, and to all auxiliaries.

An auxiliary exhaust pipe, of copper, is connected to all the auxiliary machinery. It has valves to direct the exhaust steam into either main or auxiliary condenser, either low pressure receiver, either feed water heater, or into the after escape pipe.

OFFICIAL PRELIMINARY TRIALS.

The *Louisiana* left Newport News, Virginia, for Rockland, Maine, on Saturday morning, December 9, 1905, but owing to bad weather she was detained at the mouth of the Chesapeake Bay until the afternoon of the following day. Heavy and thick weather was encountered, and Rockland was not reached until late Tuesday afternoon (12th).

The standardization trial was run on the government measured mile course off Rockland, on Wednesday morning, December 13. The weather was fine and clear, with a smooth sea. Twelve progressive runs were made over the course, the data obtained being tabulated here. The curves, page 168, are plotted from this data.

From the results obtained, 119.1 revolutions per minute of the main engines was found to be necessary to make the contract

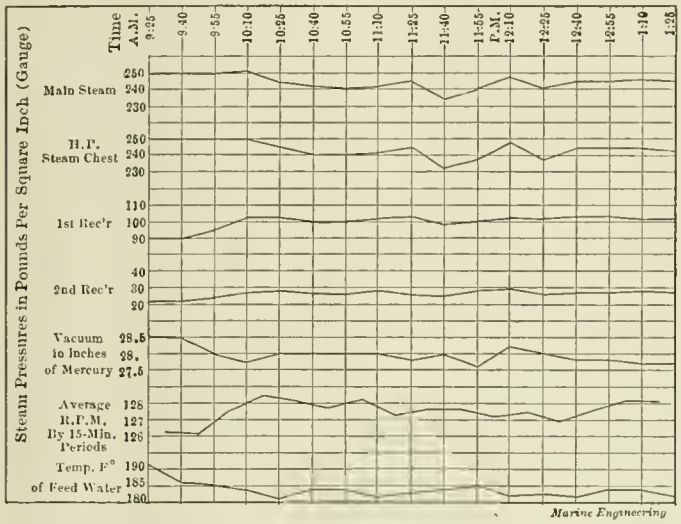


CHART OF STARBOARD ENGINE DATA, FOUR-HOUR TRIAL.

speed of 18 knots. The progressive runs were highly satisfactory, as a glance at the table and curves will show, and gave positive assurance that the speed, on the four-hour run, would easily exceed the requirement.

FOUR HOURS' TRIAL.

The following day was selected for the four-hour trial. It was run at sea, between Rockland and Boston. Fine weather and a smooth sea were again encountered, and an average speed of

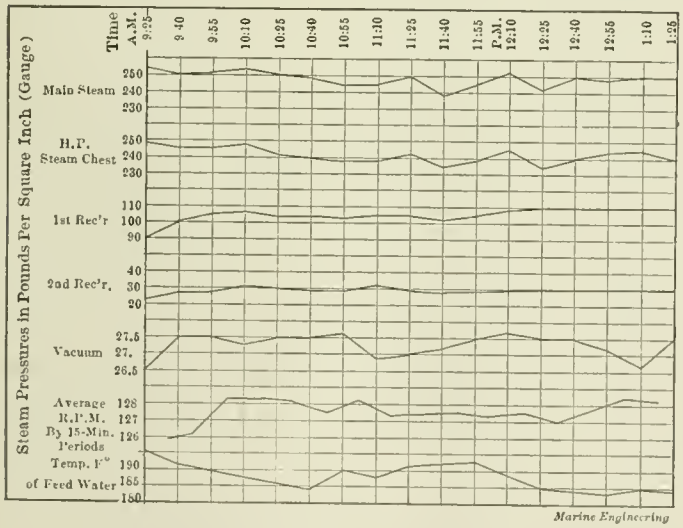


CHART OF PORT ENGINE DATA, FOUR-HOUR TRIAL.

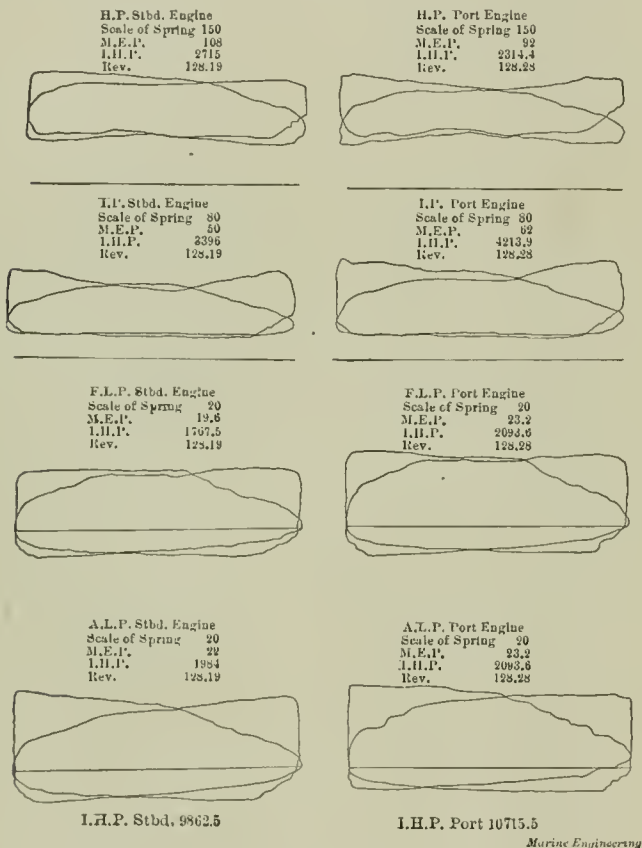
18,823 knots was maintained for the four hours. The revolutions averaged 127.67 per minute, and the engines developed 20,442.5 indicated horsepower. The operation of the machinery plant during this run was of the highest order, and the results of the trial were most gratifying to all concerned.

A set of indicator cards taken during the four-hour run is reproduced. On pages 172 and 173 are shown graphically the variations in the steam pressures, etc., throughout the run. The data obtained follows.

U. S. S. LOUISIANA. DATA FROM STANDARDIZATION RUNS ON MEASURED MILE OFF ROCKLAND, MAINE, WEDNESDAY, DECEMBER 13, 1905.

Number and Direction of run	Time on Course Min.	Time on Course Sec.	Which Engine	REVOLUTIONS OF MAIN ENGINES PER MINUTE: To Make One Knot	REVOLUTIONS OF MAIN ENGINES PER MINUTE: Average	Speed in Knots	INDICATED HORSEPOWER: MAIN ENGINES: H. P. Cyl.	I. P. Cyl.	F. L. P. Cyl.	A. L. P. Cyl.	Total	Total Both Engines	Auxiliaries in Operation	Total All Machin'ry	STEAM PRESSURES: GAUGE: In Boilers	At Engine	ABSOLUTE: H.P. St'm Chest	1st Rec'r	2nd Rec'r	MEAN EFFECTIVE PRESSURES: H. P. Cyl.	I. P. Cyl.	F. L. P. Cyl.	A. L. P. Cyl.	Referred to L.P. Cyls.	Vacuum in Inches	Air Pressure in Inches of Water	CUT-OFF IN CYLINDERS: H. P.	I. P.	F. L. P.	A. L. P.
1-S	3	14.1	S	402.2	124.23	18.547	2972	2895.8	1607.9	1660.3	9136		713.2		263.2	248	250	105	36	122	44	45	18.4	19	52.2	26.5	1.09	F. G.	FULL GEAR	FULL GEAR	FULL GEAR
			P	399.25	123.33										263.2	250	255	100	32			45.3				26.6		F. G.			
2-N	3	14.45	S	403.35	124.98	18.514	2990.2	2979.7	1617.7	1758.4	9346	18548.8	817.4	19366.2	270.9	250	260	105	36	122			18.4	20	53.16	26.8	1.31	F. G.			
			P	403.2	124.93		2891	2998.5	1669.8	1643.5	9202.8				270.9	252	260	102	32.7	118			19	18.7	52.36	26.6		F. G.			
3-S	3	14.47	S	404.85	124.89	18.512	2988	2858.5	1581.4	1704.4	9132.3	18351.5	775.2	19126.7	268.5	250	257	105	36	122			18.7	19.4	51.98	26.6	1.30	.76			
			P	403.45	124.46		2928.9	3033.3	1637.3	1619.7	9219.2				268.5	255	257	101	32.5	120			18.5	18.5	52.64	26.7		.76			
4-N	3	13.4	S	405.55	125.43	18.614	3050.2	3023.7	1623.5	1720.6	9418	18840.5	752.5	19593.0	273.5	255	262	105	37.5	124			18.4	19.5	53.36	26.2	1.35	.76			
			P	405.2	125.32		2973.8	3107.4	1701.5	1639.8	9422.5				273.5	260	265	105	33	121			19.3	18.6	53.44	26.7		.76			
5-S	3	10.25	S	401.6	126.49	18.922	3150.3	3082.9	1619.5	1824.2	9676.9	19315.1	783.9	20099.0	282.3	265	270	106	38	127			18.2	20.5	54.37	26	1.36	.76			
			P	400.5	126.14		3067.4	3101.1	1668.3	1801.4	9638.2				282.3	270	272	106	34	124			18.8	20.3	54.3	26.6		.76			
6-N	3	17.3	S	402	122.38	18.246	2940	2788.1	1394.7	1635.7	8758.5	17647.4	654.3	18301.7	268.2	250	255	97	35	122.5	43	44.5	16.2	19	50.87	26.4	1.09	.735			
			P	403.2	122.74		2895.6	2893.7	1528.2	1571.4	8888.9				268.2	255	257	98	31.5	120.3			17.7	18.2	51.51	26.6		.735			
7-S	3	17	S	391.75	119.32	18.274	2796.3	2282.1	1207.5	1418.6	7764.5	15826.1	604.6	16430.7	256.9	235	245	85	31	119.5	36.1		15.1	16.9	46.25	27.5	.91	.675			
			P	391.85	119.35		2820.4	2529.3	1351.7	1360.2	8061.6				256.9	245	250	87.5	37.5	120.5	40		16.1	16.2	48	26.8		.675			
8-N	3	31	S	400.35	113.79	17.062	2800.5	2073.9	1024.6	1120.7	7019.7	13990.8	555.2	14546.0	259	242	255	73	36	125.5	34.4		12.8	14	43.84	27.8	.83	.56			
			P	404.45	114.96		2615.3	2131.8	1091.8	1132.2	6971.1				259	245	258	77.5	34	116	35		13.5	14	43.1	27.5		.56			
9-S	3	26.5	S	379.1	110.05	17.433	2589.8	1795.8	882.6	983.2	6251.4	12361.4	449.4	12810.8	252	240	251	65	24.2	120	30.8		11.4	12.7	40.38	27.6	.40	.5			
			P	378.55	109.89		2553.9	1793.4	850.4	912.3	6110				252	245	257	56	20.4	118.5	30.8		11	11.8	39.51	27.6		.5			
10-N	3	47	S	377.9	105.24	15.859	2318.6	1589.1	718.1	762.6	5388.4	10551.2	303.1	10854.3	256.4	245	242	60	21.5	107.5	28.5		9.7	10.3	35.71	27.9	.08	.5			
			P	397.45	105.12		2226.4	1487	732.1	717.3	5162.8				256.4	240	240	55	17	108	26.7		9.9	9.7	34.89	27.5		.5			
11-S	3	35.3	S	370.1	103.95	16.721	2122	1446.9	717.7	775.7	5062.3	9760.3	293.8	10054.1	270.4	260	240	55	20.3	105	26.5		9.9	10.7	34.92	27.7	.03	.5			
			P	367.25	102.26		2005.5	1354.5	654.6	683.4	4698				270.4	262	237	54	16.7	100	25		9.1	9.5	32.65	27.1		.5			
12-N	4	13.8	S	396.35	93.81	14.184	1508.5	1093.7	494.9	521.4	3618.5	7113.5	293.1	7410.6	253.8	245	200	45	16.5	82	22		7.5	7.9	27.38	27.8	.02	.5			
			P	394.75	93.43		1502	1040	479.8	473.2	3405.5				253.8	252	200	44	15.5	82	21		7.3	7.2	26.59	27.3		.5			

	Starboard	Port
Steam pressure at boilers (gauge)	270.4	
engine room (gauge)	243.6	247
H. P. steam chest (gauge)	242.1	236.5
1st. Receiver (absolute)	114	119
2d. " (")	40.9	44.7
Vacuum in condensers, inches of mercury	26.5	26.5
Revolutions of main engines (mean)	127.66	127.69
average for both	127.675	
circulating pumps	162.3	148.8
blower engines, average	517	
Double strokes of main air pumps	21.5	21.9
main feed pumps	28.25	30.25
fire and bilge pumps	66.7	61.5
auxiliary condenser, air and circulating pump	30	
Speed of ship, knots	18.823	



INDICATOR CARDS FROM OFFICIAL FOUR-HOUR TRIAL.

Slip of propellers, in percent of their own speed, based on mean pitch	16.99	17.01
Air pressure in five room, inches of water	1.98	
Mean effective pressures, main engines:		
H. P. cylinder	108.2	99.4
I. P. "	49.6	57.3
F. L. P. "	19.8	23.8
A. L. P. "	22.4	23.4
Mean equivalent pressure in pounds per square inch referred to combined area of L. P. pistons,	54.85	59.04
Indicated horsepower, main engines:		
H. P. cylinder	2,707.1	2,485.5
I. P. "	3,349.9	3,873.1
F. L. P. "	1,780.3	2,138.4
A. L. P. "	2,006.9	2,101.3
Total	9,844.2	10,598.3
Total, both main engines	20,442.5	
Main air pumps	12.25	12.62
Circulating pump engines	48.5	38
Main feed pumps	94.5	99.2
Fire and bilge pumps	15.2	13.6
Auxiliary condenser, air and circulating pump	1.9	
Blower engines	444	
Dynamo engine (1 100-Kw. dynamo)	128.2	
Total auxiliary machinery	907.97	
Total all machinery in operation	21,350.47	
Coal, kind and quality	New River, hand picked	
pounds per hour	42,112	
" " square foot of G. S. per hour	38.39	
" " " " " H. S. " "	0.798	
" " I. H. P. per hour of all machinery in operation	1.973	
I. H. P. (total) per square foot of G. S.	19.46	
" (") " " " " H. S.	0.4047	
Temperature, atmosphere, degrees F.	34.5	
Engine rooms, upper platform	88.9	
lower "	71.3	
Fire rooms, above grating	66.8	
working level	64.5	
injection water	42	
overboard delivery	113.9	
hotwell, maximum	116	
minimum	92	
average	101.6	
main feed, maximum	194	
minimum	180	
average	185.3	
smoke pipes, base, maximum	650	
minimum	550	
average	598	

STABILITY CALCULATIONS BY PLANIMETER.

BY R. E. ANDERSON.

In designing small sailing craft and launches, the investigation of their stability is frequently neglected because of the length of time required for the arithmetic computation, and the cost of the integrator whereby the stability is more rapidly determinable. This has led the writer to propose the method which is discussed herein, and which requires a planimeter of the least expensive type, the instrument used in the preparation of this paper being one with a fixed arm. The principle upon which the method is based is the familiar property of the curve of displacement, although it is applied in a special manner.

Suppose Fig. 1 to represent a ship and *K D* its curve of displacement. That is, *K D* is a curve so constructed that each ordinate represents by its length the displacement of the vessel when immersed to the corresponding water line. If now, with the ship floating at the water line *W L*, we measure the area of the curve of displacement up to *W L*, that is, the area *C K A*, and divide it by the length of its final ordinate *C A*, we get a value which being measured down from *C* gives *B*, the center of buoyancy.*

But this property of the curve of displacement is in no wise dependent on the solid's being a ship's form, nor on the vertical immersion of the solid. Let Fig. 2 represent any solid. Now ridding ourselves entirely of the idea of immersion, let us suppose that the curve *W T* represents, by the ordinates as measured from *L W*, the successive *volumes* which would be cut off by planes *ab, cd, ef*, etc. Then if we measure the area of the curve *L W T* and divide it by the ordinate *L T*, we get the value *L B*, which measured from *L* gives the distance that the center of gravity is from the tangent plane *N M*. This locates, not the center of gravity in the direction of *N M*, but only its distance from the plane.

*See Attwood's Theoretical Naval Architecture, Appendix A, for proof.

Returning now to a ship shaped form, Fig. 3, and taking the ship inclined at an angle, we are interested only with the part *W L K* which is below the water line, and this may be considered simply as an irregular solid like Fig. 2. We can then construct a curve *W T*, which will represent by its ordinates as measured from *W L* the successive volumes cut off by the planes *ab, cd, ef,* etc. Then by measuring the area *W L T* of this curve, and dividing it by the last ordinate *L T*, we get the distance *L B* that the center of gravity of this solid is from the plane *L M*. But by taking the line *L M* and the various planes *ab, cd, ef,* etc., all perpendicular to the water line *W L*, what we really get is the location of the vertical line through which the buoyancy of the vessel acts. And if we know the position of *G*, the center of gravity of the vessel, we can at once measure *G Z*, the righting lever.

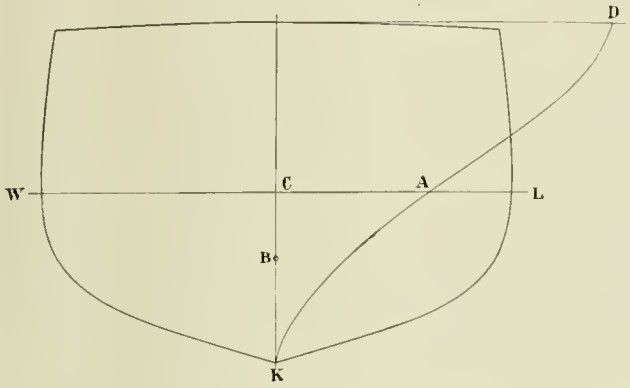


FIGURE 1.

In the practical application of this principle to the stability calculation, use is made of the Tchebycheff rule for three ordinates. (See paper by Professor Biles in the *Transactions of Institute of Engineers and Shipbuilders in Scotland* for 1899.)

In Fig. 4, to find the area of the curve *A B C D*, erect an ordinate bisecting the base and two other ordinates each distant from the middle ordinate $\frac{1}{2} l \times \frac{1}{2} \sqrt{2}$. The area of the figure is the sum of these three ordinates, multiplied by the length of the base, and divided by the number of ordinates, or $A = \frac{l \Sigma}{n}$. It will be seen that any number of ordinates may be obtained by dividing the base up into equal parts and applying this rule for the three ordinates to each part. The summation of ordinates does not have to be made separately.

The particular advantage of the Tchebycheff rule for our work lies in the fact that the simple sum of the ordinates is required, not the sum of functions of ordinates as in Simpson's rule; and if we have a body plan with sections spaced according to the Tchebycheff rule we can obtain the volume displaced up to any given water line by simply going over the sections successively with the planimeter. The instrument does the adding for us, and all that is necessary is to read the final area, multiply it by the length of the ship, and divide it by the number of sections This facility of adding the ordinate areas with the planimeter itself is of especial importance in constructing curve *W T* of Fig. 3.

The practical performance of the calculation will be best understood by following an actual case. The ship used as an example is a torpedo boat destroyer, 240 feet long, 23 feet beam, 14 feet 6 inches deep, and 7 feet 9 inches draft, displacing 564 tons.

The first operation is the construction of a Tchebycheff body plan. We decide to apply the rule three times, thus obtaining nine ordinates. The length is therefore divided into three parts, *Sa, ab,* and *bB*, Fig. 5, and to each of these parts the rule for three ordinates is applied by the following graphical method: *Sa* is bisected at *c*, *ab* at *d*, and *bB* at *e*. Now with *ca* as hypotenuse, a right angle triangle is constructed having two legs *cg* and *ag* equal.

Now $cg = ca \ \frac{1}{2} \sqrt{2}$ and since $ca = \frac{1}{2} l$, we have the required distance, $\frac{1}{2} l \times \frac{1}{2} \sqrt{2}$ to be laid off each way from each middle ordinate. Laying off this distance *cg* then each way from *c, d,* and *e*, we have the positions of the nine ordinates. It should be noted that *a, b,* and *c*, are not positions of ordinates but only the points of division between the successive applications of the rule, and are therefore discarded.

The body plan is now drawn in accordance with this spacing of sections. It is necessary to draw the sections for both sides of the ship, and it is convenient to show the sections of the after body either in red ink or in dotted lines.

The planimeter is now set with its index at zero and the tracing point resting at *a* (Fig. 6). The tracing point is then moved to the right along the water line *W L* until it meets section No. 1, which it follows around to the water line again; then it is moved to the right along *W L* until it meets section No. 2, which it traverses back to the water line. This is continued until all the sections have been traversed, and the tracing point again rests at *a*. The area of each section traversed is thus added by the instrument to that of the preceding sections, and the final reading, when corrected for scales, is the sum of the areas of the sections.

In our example this final reading was 184.95; as the instrument recorded only up to 100 the actual reading was 84.95, but the 100 mark had been once passed. Throughout this planimeter calculation this is a point to be watched, and the reading of the wheel should be roughly noted several times while taking a sum of areas.

Our instrument recorded actual square inches, and as the drawing was to a scale of one-half inch to the foot, each square inch represented four square feet. The real sum of the areas

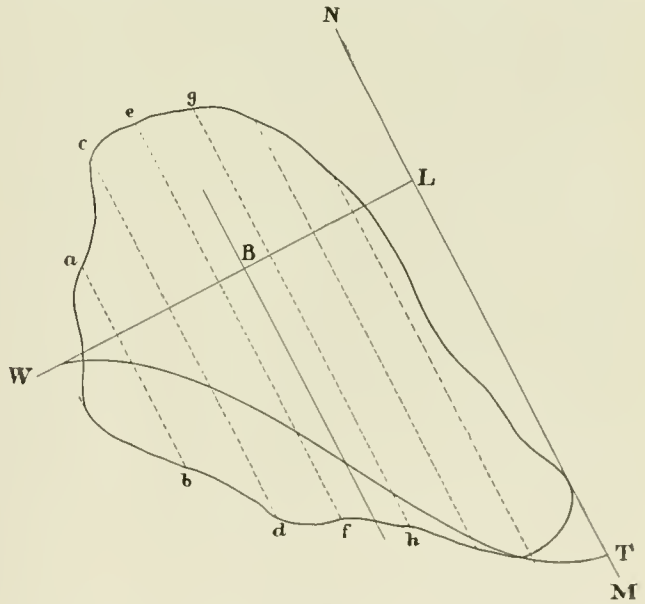


FIGURE 2.

of the sections was therefore 4 × 184.95, or 739.8 square feet. The length of the ship being 240 feet and there being nine ordinates, the multiplier according to the Tchebycheff rule is $\frac{240}{9}$. The displacement is therefore $\frac{184.95 \times 4 \times 240}{9} = 19{,}728$ cubic feet, which, divided by 35, gives 564 tons.

We have carried this matter of displacement through to a result in tons because it is a useful check if the displacement has been separately calculated by other means, and is desired as a result if it has not been previously calculated. In the stability calculation itself however, we work, not with the tons displacement, but with the original number obtained with the planimeter,

184.95, which represents simply the planimeter reading corresponding to the displacement.

We are now ready to incline the ship to a series of angles and determine the value of the righting lever for each angle. In our example we have inclined the ship to 30°.

The first problem is to find the true water line. For this purpose we draw in pencil a trial water line as nearly in its correct position as our judgment will allow, and with the planimeter take the sum of the areas of the sections below this trial water line. In Fig. 6, *wl* was the water line so chosen, and the final reading of the planimeter was 190.32; it should have been 184.85, so that this trial line is too high. A second trial line *w'l'* is drawn. It is convenient to make the trial lines some even distance apart, and in this case we chose 0.2 inch. The area below w'l' is now measured. In the example the reading was 175.64, which is too low.

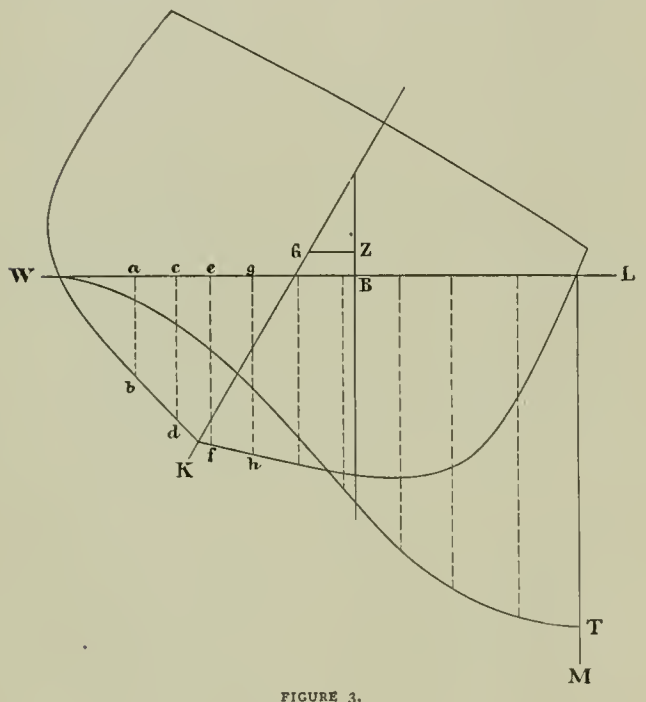


FIGURE 3.

The true water line evidently lies between the two trial lines, and it may be located by a simple proportion, since the trial lines are near enough together to make any error inappreciable. The difference between the true reading and the reading up to *wl* was 190.32 — 184.95 = 5.37; the difference between the true reading and the reading up to *w'l'* was 184.95 — 175.64 = 9.31. If then we call *d* the distance between *wl* and *w'l'*, and the distance between *w'l'* and the true water line, *x*, we have *x*: (*d*—*x*) = 9.31: 5.37. Putting in for *d* its true value 0.2 and solving, we have *x* = 0.127 inch.

The true water line *W'L'* may now be drawn in pencil 0.127 inch above *w'l'*. Testing this with the planimeter, the water line *W'L'* was found to give the correct reading within about one-tenth of one percent. If both trial lines had given too great a reading, or if both had given too small a reading, a proportion is easily established to suit the case. The error due to the use of such a proportion will of course depend on the distance between the trial lines, and their distance from the true water line.

A straight line is now drawn in ink on a piece of tracing paper, with a series of lines perpendicular to it. These perpendiculars may be any distance apart and the spacing need not necessarily be even. This tracing paper is then placed over the body plan with the straight line first drawn covering the true inclined water line, and the last perpendicular touching the farthest immersed point of the body plan, as shown at *i*, Fig. 6.

The planimeter is now set at zero with the tracing point resting at *b*. The tracing point is now made to travel to the right from *b* to *k*, to *r*, to *b*; thence to *m*, to *n*, and back to *b*, and so on, traversing in turn that part of each section which lies to the left of the *b* perpendicular and below *W'L'*. The final reading of the planimeter is now set upon the *b* perpendicular from *W'L'* as a base, using any convenient scale. In the example the reading was 5.07, and the scale selected was the 20 scale, so that one-half inch of ordinate represented 10 units of planimeter reading.

The area below *W'L'* and to the left of the *c* perpendicular is now found, and the reading set up to the scale. This is done for each perpendicular, so that each ordinate represents the total area below *W'L'* and to the left of itself. The integral curve *ps* is now carefully drawn in pencil, observing that it will come in tangent to *W'L'* at *p*, and perpendicular to *si* at *s*.

In obtaining the areas up to the successive perpendiculars, a very useful triple check may be had with very little extra work. If, when the area to the left of *b* has been obtained, the planimeter be not reset, but made to traverse the sections lying between the perpendiculars *b* and *c*, the effect will be to add this included area to that already obtained for *b*, and the final reading will be the area up to *c*. Moving the planimeter now to *c*, and setting it at zero, the total area to the left of *c* is separately obtained, and should check that previously found by the instrumental addition. The instrument is then used to add to the *c* area the area between *c* and *d*, when it is moved to *d* and the *d* area obtained separately; and so on for all perpendiculars.

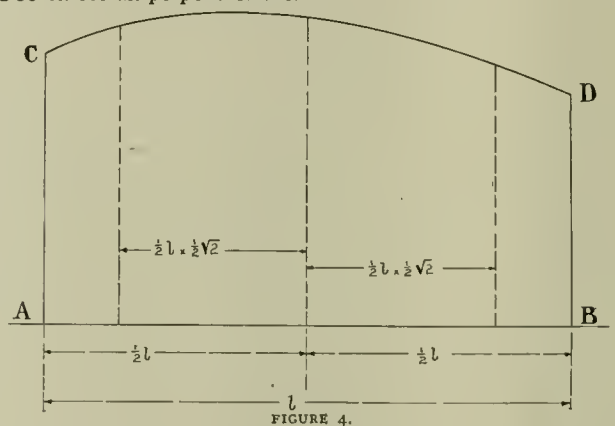


FIGURE 4.

Just how this serves to detect and avoid error will be seen by observing the results which were obtained in the example, and which are presented below:

PLANIMETER READINGS.

up to *b*	5.07	
adding between *b* and *c*	20.84	
up to *c* separately	20.82	
adding between *c* and *d*	58.27	
up to *d* separately	58.25	
adding between *d* and *e*	96.55	?
up to *e* separately	96.62	
adding between *e* and *f*	134.23	
up to *f* separately	134.23	
adding between *f* and *g*	161.65	
up to *g* separately	161.82	?
adding between *g* and *h*	179.73	?
up to *h* separately	179.54	
adding between *h* and *i*	185.12	
up to *i* separately	184.95	

It will be observed that, except in the three cases marked with interrogation points, the agreement was within one-tenth of one percent.

For the *e* perpendicular, however, the results did not check; so we continued to the *f* perpendicular, where the results did

check. It was safe to conclude that both results for *f* were virtually correct, and as one of them was obtained by adding to the independent *e* result, the inference was that the result "up to *e* separately" was correct, and that the value 96.55 was in error.

For the *g* perpendicular there was disagreement, and also for the *h* perpendicular. But for the *i* perpendicular there was virtual agreement (the error being less than one-tenth of one percent). So we accepted the 179.54 reading for *h*, because the correct sum reading for *i* was dependent on it. Having decided that the summation reading for *h* was wrong, and as this depended on the reading "up to *g* separately," which also disagreed with its mate, the inference was that the " up to *g* separately" reading was also wrong, and the figure 161.65 was consequently accepted as correct for *g*. It will thus be seen that this system of checking not only detects any error but shows at once which is the correct figure.

The area of the integral curve is now obtained in *actual square inches*. In our example this area was 51.7 square inches. This is now divided by the last ordinate, *si*, in actual inches (9.256 inches in this case) so that we have $\frac{51.7}{9.256} = 5.59$ inches, which is to be measured back in actual inches from *i* on *W'L'*, giving a point through which the perpendicular *ZB'* is drawn. This is the required perpendicular through the center of buoyancy, and if the center of gravity of the ship be assumed to be at *G*, then *GZ* is the righting lever, and may be directly measured and transferred as an ordinate of the curve of statical stability, the other ordinates of which are obtained by repeating the process for various angles of inclination.

In proceeding to a new angle, the same piece of tracing paper may be used with its inked-in set of perpendiculars, and the pencilled curve on it may be erased. We can, however, avoid the necessity of going through the process for the smaller angles of inclination by application of the property of the tangent to the stability curve. If from this origin a straight line be drawn tangent to the curve of righting levers, this tangent will, at the point corresponding to 57.3° inclination, intercept an ordinate which is equal (to scale) to the metacentric height. If then we know the metacentric height we can set this up at 57.3°, draw the tangent line down to the origin, and thus obtain at once the slope of the curve at the origin. Using this tangent line as a guide it will be found that it is not necessary to obtain points for the smaller angles of inclination.

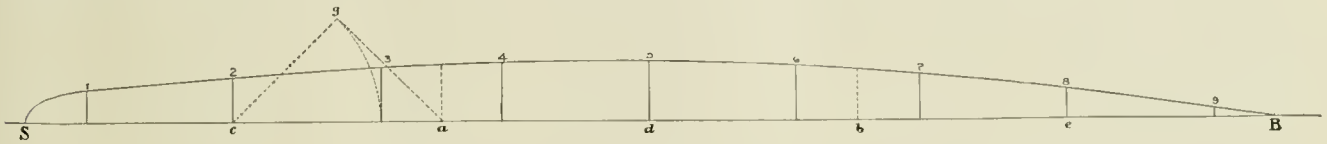


FIGURE 5.

To obtain the metacentric height it is necessary first to know the position of the center of buoyancy in the upright position. This can be found by constructing the ordinary curve of displacement, performing the integration with the planimeter between horizontal water planes up to the load water line. It is necessary to integrate only one side of the ship. Then, taking the area of the curve of displacement, and dividing by the load water line ordinate, we have the distance of *B*, Fig. 6, below the load water line. It is of course on the vertical center line.

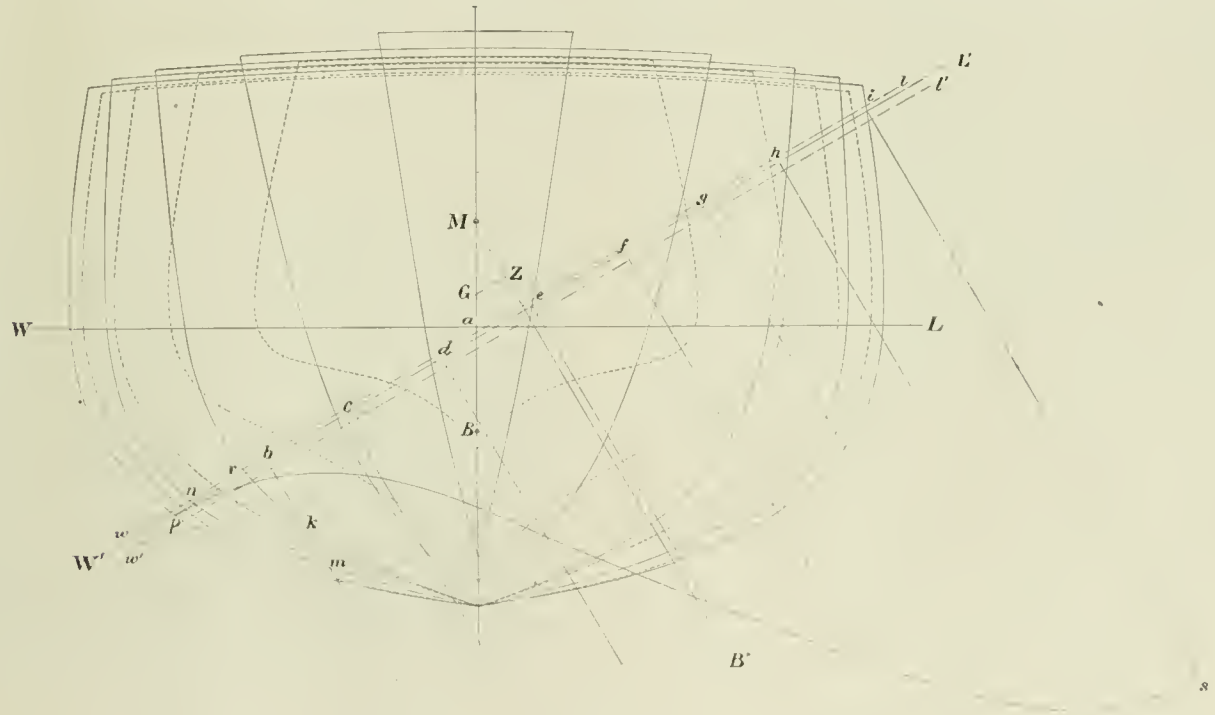


FIGURE 6.

We now obtain the *BM* arithmetically. With information already at hand this is very simple. We measure the half ordinates of the load water plane as given on the Tchebycheff body plan, keeping the measurements in actual inches; then cube each half ordinate, add the cubes, and take two-thirds of the sum. Dividing this by the square inches reading of the planimeter, which was obtained in the beginning as corresponding to load displacement, we have the metacentric height to the same scale as the drawing—that is, we have a distance which, measured up from *B*, Fig. 6, in actual inches, gives *M*, the transverse metacenter.

Thus in the ship used for illustration, the sum of the cubes of the half ordinates was 819.24; the original reading of the planimeter for load displacement was 184.95; we have therefore

$\frac{1}{3} \cdot \frac{819.24}{184.95} = 2.95$. This is of course the ordinary formula $BM = \frac{I}{V}$. Tchebycheff multipliers cancel out and leave the formula in the simplified form given.

We now have M, and it remains only to measure GM on our drawing and transfer it to the curve of righting levers drawing, erecting it from the point on the base which represents 57.3°, and drawing the tangent line to the origin.

The selection of the angles at which to incline the ship will of course depend on the type of the ship. In general the calculation should be performed for the angle at which the deck edge begins to be immersed, for several smaller angles, and for one or two greater angles.

After the curve of righting levers has been plotted, it will probably be found that the maximum stability does not occur exactly at one of the angles for which we have made the calculation. The curve as we have plotted it, however, will give with a reasonable degree of closeness the angle at which the maximum

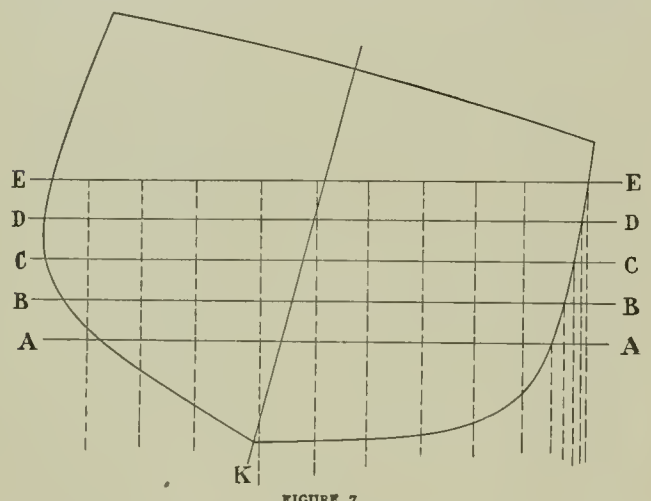


FIGURE 7.

stability does occur, and we can then locate the water line corresponding with that angle, and, performing our calculation for that water line, check the value of the maximum righting lever. The same may be done for the point at which the curve crosses the base—that is, the point at the extreme range of stability.

CROSS CURVES OF STABILITY.

Although the ordinary curve of statical stability is often all that is required, cross curves of stability can easily be directly determined by the same method, and if the ordinary curve is also desired it can be plotted from the cross curves. The cross curves require only a little more work to obtain by this method than does the ordinary curve, and this is more than offset by their greater usefulness.

Let Fig. 7 represent our Tchebycheff body plan. We cover it with a piece of tracing paper and draw, at the first of our series of angles, which is, say, 15°, a series of water lines, *AA, BB, CC*, etc. They may be at any convenient distance apart, and need not be evenly spaced. They should, however, be so located that one or two will be above the probable location of the inclined load water line, and two or three below it. The perpendiculars are now so drawn that there is one perpendicular from each water line at the point where it leaves the body plan on the immersed side. The other perpendiculars are spaced at will.

We now consider the ship as immersed to *AA*, and perform the calculation as outlined above, drawing the integral curve, taking the area and dividing by the last ordinate, thus obtaining the vertical through the corresponding center of buoyancy. This last ordinate, when corrected for the scales of the drawing and of the planimeter, gives of course the displacement up to *AA*. If we know *G*, the center of gravity of the ship when floating at *AA*, we can measure *GZ*, and so locate a point on the 15° cross curve which will correspond to whatever displacement *AA* gives.

In like manner we integrate up to *BB, CC*, etc., and find *GZ* for each. We can then draw in the 15° cross curve, and proceed to the next angle of inclination.

But *G* is not in the same position for all the different conditions of loading which would result in the differing displacements. To overcome this difficulty we must either calculate or assume the position of *G* for each of a series of displacements, and from this data plot a curve giving the height of *G* above the keel for varying displacements. From this curve we can locate *G* for the displacements corresponding to *AA, BB*, etc., respectively, and so are able to measure *GZ*. This curve once constructed, answers for all angles of inclination, since the position of *G* is quite independent of the angle.

English and American Capstans and Electric Winches.

BY FRANK C. PERKINS.

Electric winches and capstans are not only utilized on harbor wharves for hauling ships, but are also employed to haul freight cars or heavily loaded trucks into and out of machine shops and other factory buildings, as well as to drag heavy material along the ground upon rollers instead of trucks. The accompanying illustration, Fig. 1, shows the general design and construction of an English capstan and controller for the same installed at Heysham harbor at Lancashire, England, for the Midland Railway Company; though this particular equipment was constructed for the Japanese government and is of a much larger capacity, being capable of hauling ten tons without difficulty, a larger motor and heavier gears being utilized with a corresponding larger capstan

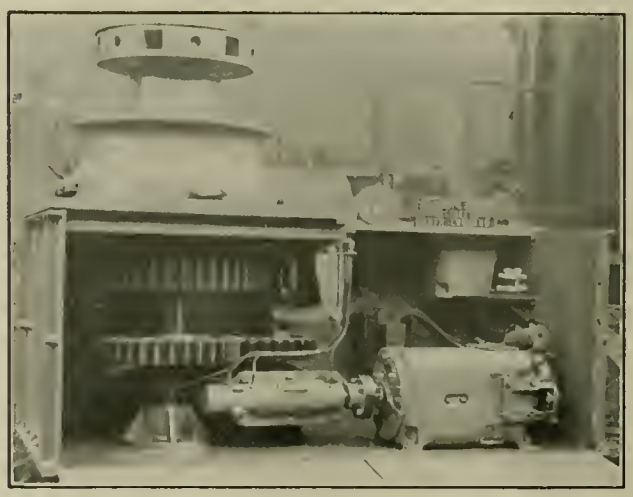


FIG. 1. ENGLISH TEN-TON ELECTRIC CAPSTAN FOR JAPAN.

box. Twelve of these electric capstans were erected at Heysham harbor wharf by Stothert & Pitt, Limited, of Bath, England. The electric motors were constructed by the British Westinghouse Company.

Figures 3 and 4 give two views of an American electric capstan or electric winch constructed by the Sprague Electric Company, of New York city, and designed to haul heavy loads short distances at slow speeds. This electric capstan will pull 1,200 pounds at a speed of 10 feet per minute, and by extending the base so as to completely inclose the motor, the apparatus can be made portable if so desired.

The capstan is equipped with a 20-horsepower compound-wound motor and starting gear of special design, a pedal gearing being arranged for controlling the same. At Heysham harbor there are two one-ton capstans and two three-ton capstans, the latter being

used for hauling ships and the former for ordinary work. On account of the pedal arrangement for starting the capstans in operation and stopping the same, a more or less difficult feature presented itself in arranging the overload cut-out and starting switch. The arrangement of the controller resistances and motor within the capstan box, as well as the driving gear, is clearly seen in the accompanying drawing, Fig. 2, and illustration, Fig. 1.

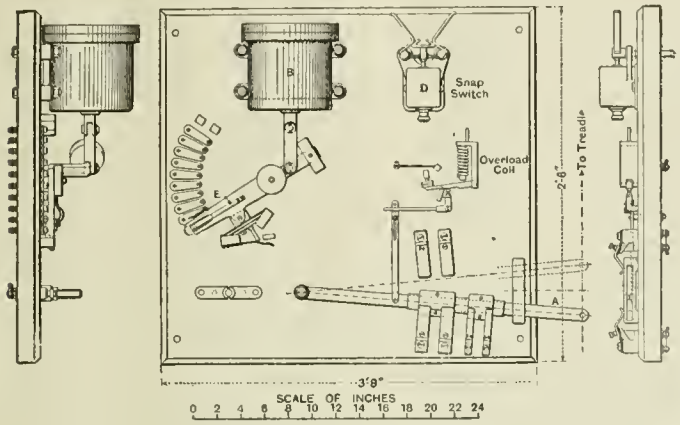


FIG. 2. ELECTRIC CAPSTAN CONTROLLER.

It will be noted that the motor is so arranged in the capstan box that its shaft is horizontal, operating through a bevel gear an intermediate vertical shaft which is connected to the capstan head by means of a single reduction spur gear. Fig. 2 shows the controller itself, which is placed within the capstan box and worked by means of the foot plunger; the lever *A* being depressed by the treadle, thereby connecting the positive main to the coil *B*. The

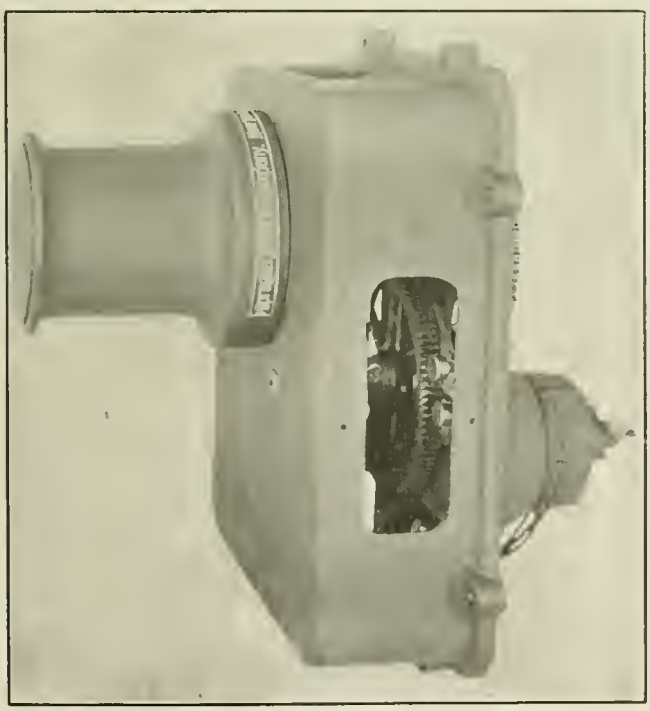


FIG. 3. SPRAGUE HEAVY DUTY ELECTRIC WINCH.

same lever closes the circuit of the coil of the switch *D* by means of two contacts. As switch *D* rises and makes contact, the circuit of coil *B* is completed with the main circuit on the negative side. The starting switch lever is then moved by the coil *B*, and the motor is immediately started. As soon as the lever of the starting switch leaves the two contacts and moves from the "off" position, a resistance is placed in the circuit of the snap-switch coil and the contacts are opened, which operate to short-circuit the lamp resistance when reaching the "on" position. Heating is thus prevented and the current consumption reduced. By making all the connections to the negative main all the sparking takes place at the contacts of the snap switch *D*, and these can be replaced without difficulty. The main contacts on lever *A* break afterward, as the subsidiary contacts which make its circuit are short, and a double pole brake is provided in this way. The main current passes through the overload coil, the resistance of the starting switch being on the positive side before coming to the contact, and in case the load on the electric winch is too great the circuit is opened by the overload coil, and the overload cut-off is held in the off position until the foot plunger is released by a catch. In case there is a heavy overload and the electric capstan comes to a dead stop the operator has only to find out the difficulty, remove the obstruction, and then depress the treadle

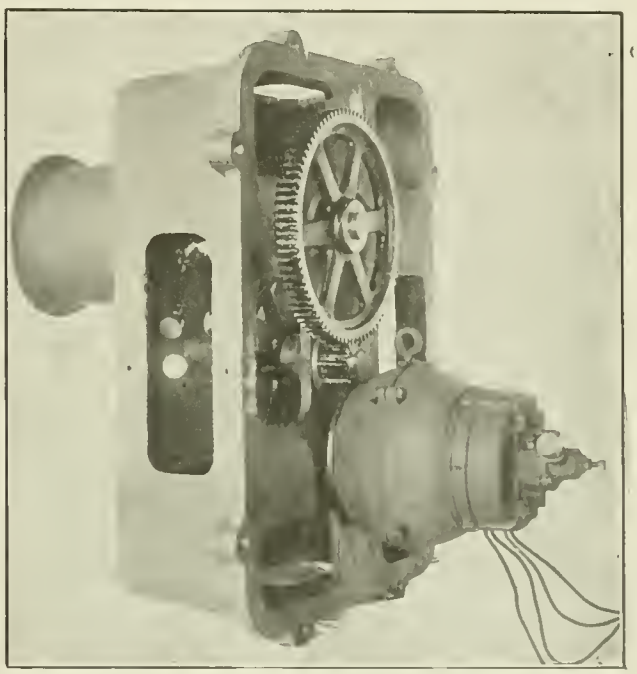


FIG. 4. SPRAGUE ELECTRIC WINCH OR CAPSTAN.

again, when the electric capstan will operate as before, there being no cut-off for him to reset. The whole arrangement is automatic in its operation, and as the cut-off gear is entirely enclosed within the capstan box, it is impossible for a laborer to disturb it or so manipulate it by tying or wedging it as to cause trouble by a desire to prevent it from operating on an overload.

The drawing, Fig. 5, shows another type of English capstan especially designed for wharves and dock yards, and capable of pulling about 2,500 pounds direct from the drum at the rate of 150 feet per minute. This mechanism was designed and constructed by John H. Wilson & Company, Limited, at their works at Sands Hill, Liverpool. It is designed to operate with continuous current or alternating current motors of the three-phase type. The worm and wheel work in an inclosed oil bath, and it will be noted that these machines require but little foundation, being entirely self-contained in a watertight cast-iron box which has merely to be let into the ground and bedded on concrete or other suitable material. For piers and jetties it is bolted to the floor beams. A special feature of these electrically-driven capstans is that they take up very little room between the railway tracks in the yards or on the docks.

It may be of interest to compare these electrically-operated capstans with the steam-driven types. The accompanying illustration, Fig. 6, shows a most compact form of English steam-driven capstan as constructed at Gateshead-on-Tyne by Clark, Chapman

& Company, Limited. To decrease its weight as far as possible the capstan spindle is carried solely by a strong support bolted to the bed plate, the covering over the gearing on the light steam warping capstan being of sheet iron, and made portable with a

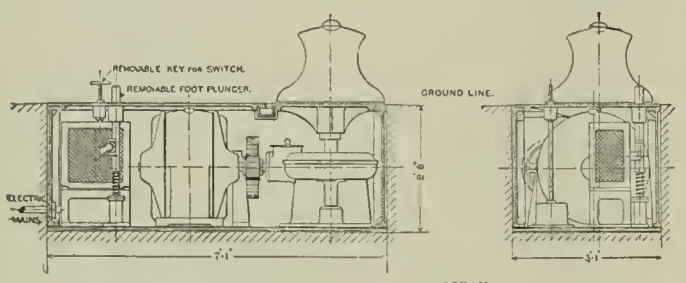


FIG. 5. ENGLISH ELECTRIC CAPSTAN.

hinged door for access to the engine crank shaft. By removing the portable plug in the capstan head the barrel is free to revolve, and can then be worked by capstan bars in the usual way, while a special safety fall is fitted for holding the barrel when working by hand and is so arranged that if properly put out of gear it cannot accidentally engage when the capstan is running by steam. It will be noted that the heavy capstan of the steam-driven type

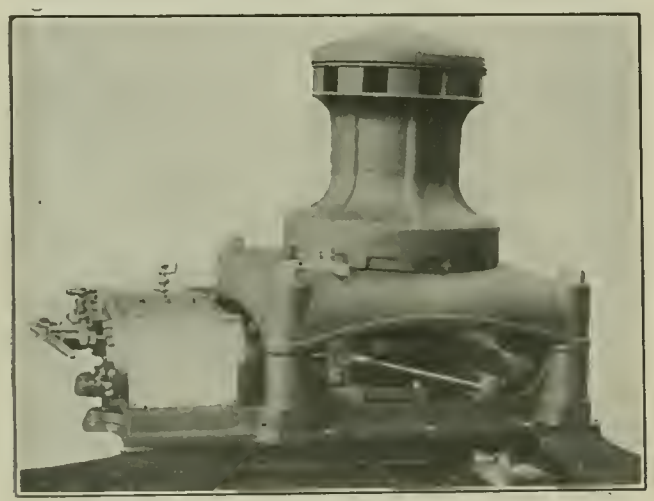


FIG. 6. AN ENGLISH STEAM DRIVEN CAPSTAN.

shown in Fig. 6 is mounted on a heavy cast-iron base with a cast-iron covering for the engine and gearing. Where the capstan is located near a steam-distribution point, as on a vessel or near a boiler plant on a wharf, a steam-driven capstan can be operated to advantage, but it is claimed by eminent engineers that electric capstans are more economical in action than steam capstans where they are located at a considerable distance from the steam generating point; the losses through condensation in the pipes carrying the steam to the engine being many times greater than the losses in the electric conductors carrying current to the motors and electric capstans.

A Dry Dock in Central Africa.

What is probably the highest dock in the world, from the viewpoint of altitude above the sea, has recently been completed at Port Florence, on the Victoria Nyanza, in Uganda, Africa, at an altitude of 3,800 feet above sea level. The dock has been constructed to accommodate the Nyanza fleet plying on the lake in conjunction with the Uganda Railroad. It measures 250 feet in length by 48 feet wide and 14 feet deep. It was excavated out of the solid rock by native labor, and occupied twelve months in construction, at a cost of $20,000. Both the time occupied and the cost of the undertaking were increased owing to plague visitations, which seriously interfered with the work.

MOTOR BOATS, XI.

BY DR. WILLIAM F. DURAND.

Turning now to the chief structural members of the boat, brief memoranda may be noted regarding materials commonly employed, and the characteristics best representative of present practice with regard to such items. We shall first assume the construction to be of wood, as is the more common practice for small boats of the type and character under consideration.

Keel. This is commonly of oak, and for the older form of stern more or less square in section, or with the greater dimension vertical, as indicated in Fig. 50; while for the more modern or torpedo boat stern, the flat keel, as indicated in Fig. 51, is more commonly employed.

The stem and the stern post, where fitted, are also commonly of oak and joined to the keel with oak or hackmatack knees.

Frames. These likewise are commonly of oak, from ½ inch to ¾ or 1 inch square, and spaced 6 inches to 8 or 9 inches between centers, both size and spacing increasing with the general size of the boat, and varying otherwise with the general character of the construction.

Deck Beams. These may be of oak (sometimes of spruce or even pine) and are spaced to suit the frames, and in section may vary with size and general character of construction from ½ to 1 inch in width by 1 to 2 inches in depth.

Deck Planking. This is commonly of pine or cedar, ⅜ to ½ or ¾ inch thick, and often covered with canvas laid in white lead or varnish, as a water-proof covering.

Side Planking. This may be of cedar, pine or mahogany, either single or double, and may vary in total thickness from as little as ¼ inch to 1 inch or more, according to size and character of construction. In ordinary construction, where saving of weight is of no special importance, one layer of ⅞- to 1-inch or even 1⅛-inch stuff represents in general the most serviceable form of planking in proportion to the expense involved. In such form of outer covering special attention must of course be given to the seams with reference to painting and calking, points which will be taken up at a later time. A much more generally satisfactory covering, especially with reference to the ease of keeping water-tight, may be obtained by the use of two layers each ⅜ to ½ inch in thickness, with white lead between and with the joints carefully shifted as between the inner and outer layers. In special construction for high speed boats, cedar or mahogany in layers ¼ or $\frac{5}{16}$ inch thick is employed, and sometimes with a layer of silk or like fabric carrying oil or varnish as a form of stop-water between the layers of wood.

Fastenings. These may be copper rivets and burrs, copper nails clinched or riveted over burrs, screw fastenings of various and special forms, or plain galvanized iron nails and common screws. In all first class work only copper, brass or special bronze is used for fastenings, and wherever practicable they should be "through and through" rather than driven."

Water-tight Bulkheads. In the best modern practice it has become customary to provide for the subdivision of the boat into water-tight compartments by means of bulkheads which must be very carefully designed and fitted, with reference to both strength and water-tightness. From three to five such compartments are considered suitable in cases of typical modern design. The purpose should be to so proportion these compartments that the boat may still float with any one of them open to the sea.

In the ordinary boat with open cockpit there is usually scant room for such compartments at the bow and stern, especially if relatively large seating capacity in the cockpit is desired. If, however, the maximum of seaworthiness and safety is required, the central space must be cut down to such a point that the compartments at bow and stern can be made of size sufficient to give a small reserve of buoyancy, even with the central cockpit

flooded. These are matters which turn chiefly on the question of policy—the extent to which safety is to be sought at the loss of some degree of capacity or convenience in smooth water. The question is one, in any event, which should be carefully considered, and the most recent and representative practice seems to indicate an increasing purpose to combine the highest practicable degree of safety with such other features as the design may contemplate,

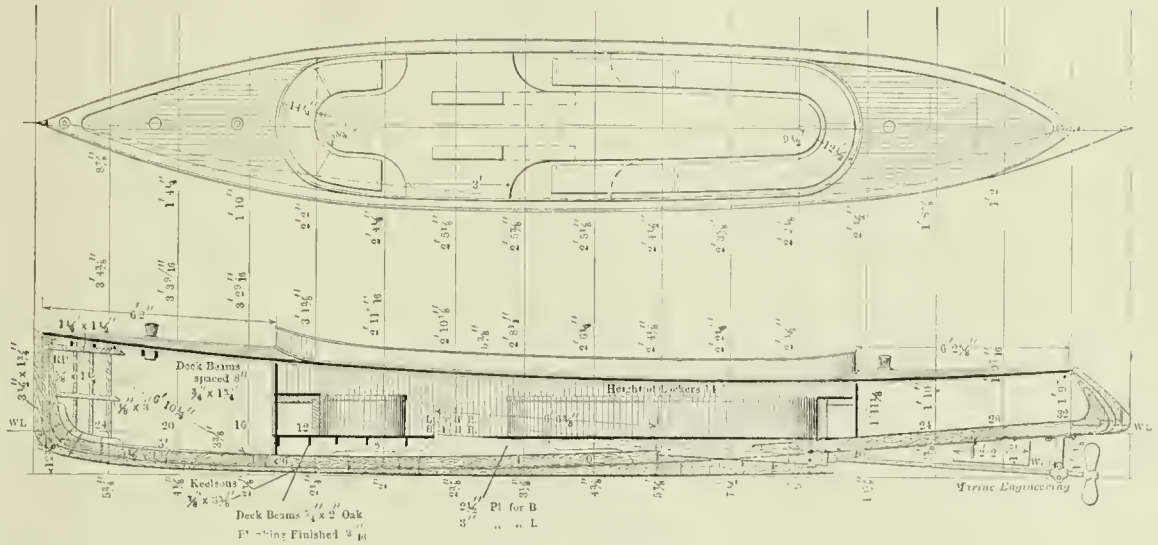


FIG. 54. INBOARD PROFILE AND DECK PLAN OF SPEED LAUNCH EUSONIA.

and to give full value to the importance of water-tight compartments in the consideration of these general questions.

It should be noted that in many respects there exists the widest range of practice between the construction of an ordinary moderate speed motor boat for runabout purposes and the special high speed racing machines, where the conditions for high speed are carried to the farthest possible extent, and involving most careful study of structural features in order to realize the maximum of strength and stiffness on the minimum of structural weight. Certain special features of construction found in boats of this type may be summarized as follows:

(1) Depending on the size of the boat, the frames are reduced in section and made of carefully selected material with a somewhat reduced spacing to offset, at least in part, the decrease in local strength caused by the reduction in thickness of side planking. With proper care in design the general balance between increase in number of frames and decrease in sectional area may be made to yield an important saving of weight as compared with the more ordinary schedule of construction.

(2) The side planking is commonly in two layers each $\frac{1}{8}$ to $\frac{5}{16}$ inch thick. In certain cases, however, a single layer of such covering is used, the seams being covered on the inside with strips worked as stringers, thus avoiding the need of calking, and effecting a saving in weight as compared with the more common double plank covering.

(3) Special diagonal bracing on the inside of the frames may be worked, adding strength against torsional stress, and aiding in the general consolidation of the framework together into an engineering structure.

(4) In certain cases special girder-like structures with top and bottom chords, timber struts for compression and steel wire for tension, have been worked along the sides of the boat inside, to aid in giving the necessary longitudinal strength against sagging and hogging stresses.

(5) Special forms of framing have been employed, as in the case of the *Standard*, and as a result of which marked saving of weight has been effected. The following brief description will give the principal features of the special framing employed in this case:*

The length over all is 60 feet and on the water line 58 feet, with an extreme beam of 7 feet 6 inches. The planking is of single thickness Honduras mahogany $\frac{1}{8}$ inch thick, and with edges secured by flush screws to continuous longitudinals of Oregon pine, after the manner noted in (2) above. The framing is carried out on a special double system consisting of inner and outer frames and longitudinals. The longitudinals are notched over the outer frames, and all three parts of the structure are through riveted, giving great transverse strength on a minimum of weight. The inner frame is furthermore carried continuous up the side and across, forming the lower member of the deck beam, while the upper member of the same runs across from side to side and ends at the plank-sheer. The longitudinal strength of the boat is obtained chiefly from two truss girders running from end to end in the wings, and consisting of upper and lower continuous longitudinals, wooden compression struts and galvanized wire diagonals set up tight, substantially as noted in (4) above.

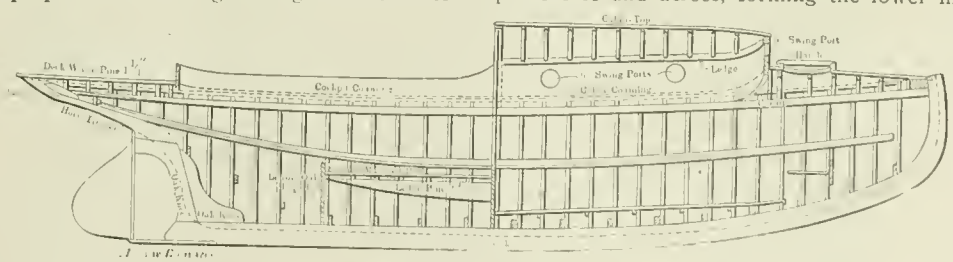


FIG. 55. LONGITUDINAL SECTION OF SMALL MOTOR BOAT, SHOWING FRAMING.

(6) Local stiffening is reduced to a considerable extent by accepting a narrower margin of safety in this direction, and by a

*See Marine Engineering, March, 1904, page 127.

careful study of the disposition of the material in such manner as to realize maximum strength for minimum weight.

As a result of special construction along these lines, results have been realized giving a weight of hull of about one-third the total ultimate displacement as compared with one-half to two-thirds for more ordinary modes of construction.

The use of structural steel for motor boats may be passed over with but brief reference. While there are not a few boats of the general motor boat type, especially in the larger sizes, which are built of structural steel, yet it must be admitted that the typical mode of construction of such boats is of wood. In cases of steel construction, furthermore, the general characteristics are similar to those met with in larger craft, or in wooden construction as well. The framing is made up of deck beams, transverse angle iron frames, longitudinal keel plate and stringer angles, with plating disposed in much the same manner as for larger craft, and fulfilling the same general functions.

Having in view the foregoing brief discription of the principles involved in practical boat construction, it will be of interest to give in some detail the following description* of the scantlings and structural features of a typical modern high speed motor boat, in which several special structural features have been introduced, and which yet represents excellent practice with respect to the main lines of small boat design and construction. See also Figs. 52 and 53 for section of this boat.

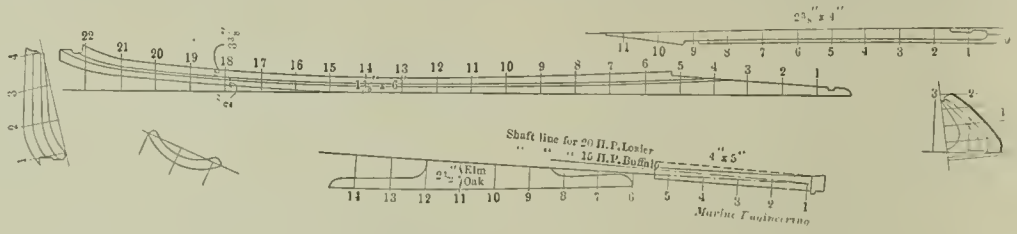


FIG. 56. DETAILS OF KEEL, STEM AND STERN, OF EUSONIA.

PRINCIPAL DIMENSIONS.

Length over all	56 feet	8 inches
Length on deck	55 feet	8 inches
Length on water line	54 feet	4 inches
Extreme beam	7 feet	
Draft	3 feet	

The boat is constructed almost entirely of wood, with fastenings of copper and Tobin bronze. At a few points castings have been used of gunmetal or manganese bronze.

The keel is of white oak made in two lengths, having a width of 4 inches at the forward end and increasing to 10 inches amidships, at which width it is continued to the stern post. The scarf between the two sections of keel has a length of 24 inches, and is fastened with five ¼-inch copper rivets and two brass screws. The keel is rabbeted to receive the side planking. The stem is of chestnut, secured to forward end of keel by means of a 32-inch scarf. The stern post is of white oak 4 inches deep, and secured to the after end of the keel and to quarter timbers by means of a hackmatack knee.

The frames are of selected white oak, extending in one length from the plank sheer to keel, from the stem to frame number 60 inclusive. In the way of quarter timbers the frames are in two lengths, connected by a hackmatack knee. From frame number 60 to quarter timbers the frames overlap the keel or center line, reaching a maximum of 16½ inches at frame number 40. All frames are spaced 8 inches between centers, and measure ⅞ by ⅞ inch at keel and ⅞ by ¾ inch at head. The frames between numbers 32 and 53 extend up above the plank sheer to form coaming and sides of turtleback.

*See Marine Engineering, September, 1905, page 372.

The floors forward of frame number 59 are of white oak measuring 1¼ by 1½ inches. Side keelsons of Oregon pine are fitted measuring 2½ inches on the siding from frame 15 to frame 59 inclusive, and diminishing to 1½ inches at the ends. The top strake measures 2½ inches for three-fifths length amidships, and 1½ inches at ends, while the figures for the bottom strake are 1½ inches and 1 inch respectively. These keelsons are connected by hackmatack floors with cedar braces and stiffeners, and also by occasional 2- by 2-inch spruce struts. Engine keelsons measuring 2½ by 3½ inches extend from frame 38 to frame 53, and carry the weight of the machinery.

The deck beams are of white oak 1¾ inches by 1 inch, except that beams at frames numbers 1 and 4 are 1¾ by 1¾ inches, and at numbers 6 and 32, 1¾ by 2½ inches, the latter dimension in each case being the siding or width. All beams are spaced one on each frame and crowned 2 inches amidships, except as modified by the turtleback structure.

The sheer strake is of white oak ⅞ inch in thickness and about 4½ inches wide, the lower edge being rabbeted to receive the double planking. It is worked with a molding 1⅛ inches in thickness as shown on sections. The bilge stringers are of clear Oregon pine in one length, 2 by 2 inches for three-fifths length amidships, tapering to 1½ by 1½ inches at the ends. The planking is in two thicknesses, with a width of 4 inches on the sides, increasing to 5 inches on the bottom. The inside thickness is of cedar, ⅛ inch thick, and the outside of mahogany, ⅜ inch thick. These are separated by Union silk covered with varnish, and are held together with button-headed brass screws.

The plank sheer is of mahogany, ⅝ inch thick on outside and ½ inch on inside and 4½ inches wide, fastened to each beam and to edges of sheer strakes with brass screws. The deck plank is of white pine ½ by 2½ inches at the stern and amidships, and ⅜ by 2 inches on turtleback, the seam being laid in white lead.

There are three bulkheads, located respectively on frames 6, 32 and 59. All are constructed of white cedar in two diagonal layers each ¼ inch in thickness, with a layer of Union silk between, covered with varnish, and all fastened together with copper rivets.

Announcement is made of the sale by the Moran Brothers Company of their shipyard in Seattle, Wash., to eastern capitalists, who will continue the operation of the plant on the lines already laid down, and which have proved so successful. It is understood that the sale price is in the neighborhood of three million dollars. The withdrawal of the Moran brothers from active control of the great enterprise which they founded twenty-four years ago is due to failing health. It is understood that the battleship *Nebraska*, which has been building in the yard since 1902, will be completed by the original firm.

The new organization, which will be known as the Moran Company, will be under the general management of George H. Higbee, while the works will be in charge of J. V. Patterson, lately naval architect at New York for the American Line.

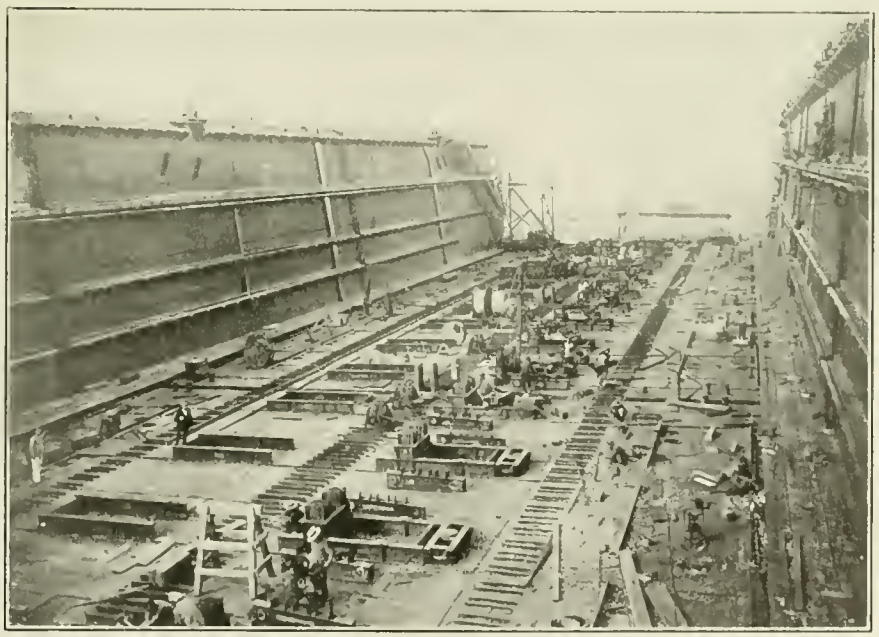
The new capital is $2,000,000, of which one-half is common and one-half 7 percent cumulative preferred. There are 10,000 shares of each.

AN INTERESTING IRON FLOATING DOCK.

There recently left the stocks at Tsingtau, China, an iron coffer or floating dock capable of lifting the biggest battleship in the world, its bearing capacity being no less than 16,000 tons. Due to the enormous dimensions of the dock in question, necessitated by its high bearing capacity, it ranks as one of the largest of its kind in the world. This dock, which has taken two years to construct, was built for the German government by the "Gutehoffnungshütte," of Oberhausen. The total weight of the construction is 8,800 tons. The dock was launched complete, ready for operation.

SIDE LAUNCHING OF IRON FLOATING DRY DOCK AT TSINGTAU.

The dock consists of five detachable bottom pontoons with superimposed lateral chambers or boxes by means of which the pontoons can be rigidly attached to each other. The entire dock has a length of 410 feet with a width of 128 feet. The height of the pontoon on the centre is 10 feet, while the lateral boxes or sidewalls are 43 feet high, so that the total height of the dock amounts to 62 feet, in round figures. Each pontoon has a length of 80 feet, and is divided into eight watertight cells by means of three longitudinal bulkheads and one main framing. The water ballast is pumped out of these cells by means of ten horizontal centrifugal pumps, two of which are located in each pontoon; they are actuated by electric-motors coupled direct to the pump rods. The starting and stopping of these motors, and the control of the slide valves required for the pumping plant, is effected by the aid of electricity from a controlling station located upon the lateral boxes. The electric current is supplied from a central station situated on the land. By means of all these devices the dock, with the vessel lying therein, can be raised within a period of two hours. In addition to the three bulkheads mentioned above each pontoon has 28 transverse framings which serve as stays. The lateral boxes or chambers are also strengthened by bulkheads and frames, which are located directly above the transverse stays of the pontoon. E. O.



DECK VIEW OF THE NEW DOCK, BUILT FOR THE GERMAN GOVERNMENT

THE MOLDING OF PROPELLERS.

BY W. F. D.

For the operation of molding and casting the screw propeller, two general methods are available, involving respectively the use of the pattern and that of the sweep. A fully detailed description of these methods would far exceed the limits of these columns, and we can therefore give only an outline of the process in either case.

For quite small propellers complete patterns are commonly employed, and insure the maximum rapidity of production. For larger propellers a hub and pattern for one blade is more commonly used, the single blade pattern being molded in as many positions as may be necessary to provide the number of blades desired. For a propeller with separable blades, a hub and single blade pattern are always employed, the blade pattern being remolded as many times as may be necessary to give the requisite number of blades. For large propellers which are not likely to be duplicated often, and for which therefore the expense for patterns could be less properly undertaken, the method of sweeping up the mold is commonly employed. The choice between the method by pattern and the method by mold is chiefly a question of the number of duplicates likely to be required. Where several propellers of the same dimensions and form are to be built, it will be advantageous to have a pattern; where only one

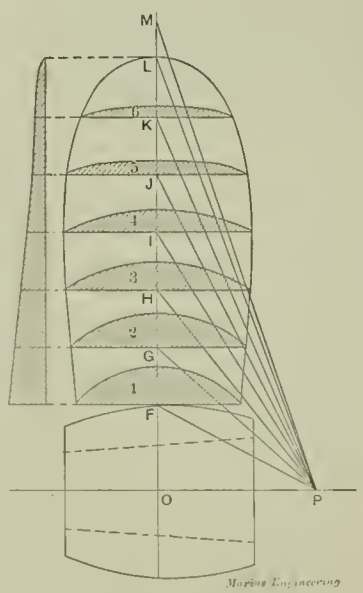


FIGURE 1.

is required, with uncertainty as to duplication, the expense of the pattern may be in large measure avoided by the use of a swept mold.

THE USE OF PATTERNS.

The construction of a screw propeller pattern implies, of course, the making in wood of an exact full sized model of the propeller, or at least of the hub and one blade. To this end the propeller drawing must furnish the following information:

(1) The general dimensions of the propeller, or more particularly *diameter* and *pitch*.
(2) The form and dimensions of the hub.
(3) The form of the developed surface of the blade.
(4) The form and inclination for each of a series of "guide iron" edges across the blade, at a series of radial distances from the hub to the tip of the blade.
(5) The lay out of thickness along a midrib from hub to tip of blade, and transversely of the blade from entering to following edge.

Such information for a uniform pitch propeller with straight radial blades is indicated in Fig. 1, and includes everything needful, no matter which method of molding the propeller be followed. It will be unnecessary to discuss in detail the pattern for the hub. An outline of the process for constructing the pattern for the blade may be indicated by the following steps:

(1) Form the pattern for the hub first as a cylinder—that is, with equal diameter throughout its length and equal to the maximum finished diameter $O F$, Fig. 1.

(2) Prepare a "surface board" or platform, smooth and level and large enough to lay out and support the pattern for the hub and one blade.

(3) Out of thin sheet metal cut a triangle similar to $P O F$, Fig. 1, and bend the same so that the side similar to $O F$ is brought to the arc of a circle of radius equal to $O F$.

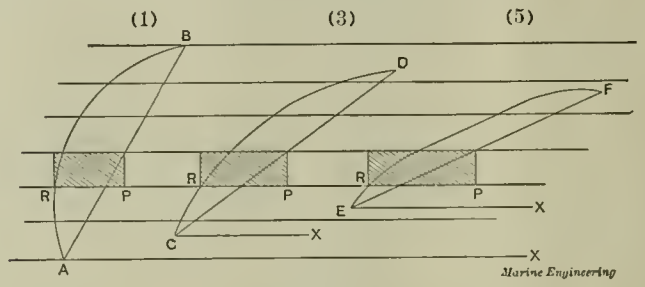


FIGURE 2.

(4) Lay this on the hub with side similar to $O P$ parallel to the axis of the hub, in which position the line similar to $P F$ will give the intersection of the blade surface with the hub.

(5) Cut a deep V-groove in the hub with one edge brought to the line determined by the hypotenuse of the curved guide as noted in (4), taking care to have the width of the groove on the side corresponding to the thickness or back of the blade, and also to cut the groove of sufficient depth near the ends of the hub to allow for such tapering off as the finished form of the hub may require.

(6) Lay out full size, and each at its own inclination, a series of blade sections, of which numbers 1, 3 and 5 of Fig. 1 are shown in Fig. 2. In each case the inclination of the lines $A B$, $C D$, etc., with the horizontal equals the inclination of the corresponding lines $P F$, $P H$, $P J$, etc., with the transverse or $O X$. Thus angle $B A X$ = angle $P F O$, $D C X = P H O$, and similarly for the entire series of sections of Fig. 1.

(7) On these inclined sections lay off a series of slices or "lifts" as shown, and representing the layers out of which the blade pattern is to be built up.

(8) Select a piece of stuff of the proper thickness for one of the lifts, and of sufficient width to give the widest of the dimensions similar to $P R$ as shown on the series of inclined sections, and for, say, lift number three from the bottom. At points F, G, H, etc., Fig. 3, representing the points similarly lettered in Fig. 1, lay off widths F 1, G 2, etc., equal respectively to the successive dimensions $P R$ of Fig. 2. Then spring a batten through the points 1, 2, 3, etc., and cut the piece with a square edge down to the line thus determined. This operation will give the form of lift number 3 for the blade pattern. Near the edges of the blade, where the contour may fall short of filling out the entire thickness of the lifts, as indicated in Fig. 2, the lift should nevertheless be continued the full length, and of sufficient width to insure a good joint with the one adjacent. When a lift runs out of the contour entirely, as near the tip for the top and bottom lifts, it may be continued of uniform width equal to that for the section nearest the point where it leaves the contour of the blade. Suitable dispositions regarding these various details will readily present themselves when dealing with the actual problem.

(9) In this general manner, therefore, the entire series of lifts is laid out and brought to form. In all such operations care should be taken to number and mark each lift so that it may be readily identified and located in place in the operation of assembling.

(10) The inner ends of the lifts, which should be left long enough for the purpose, are then beveled down so as to fit in the

V-groove in the hub, and number 1 (or that for the bottom of the blade pattern and corresponding to the after or following edge) is fitted in place in the hub and secured with dowels and glue. In fitting this in the hub the edge on the face side should be beveled off so that it will lie just in contact with the line of the guide, as determined in (4).

(11) A guide similar to the triangle $P\,K\,O$, for example, and corresponding to the radius $O\,K$, is next made and bent so that the side similar to $O\,K$ is brought to the arc of a circle whose radius is $O\,K$. This guide is then set up with side similar to $O\,P$ parallel to the hub axis, and on the circle of radius $O\,K$, and whose curvature it is bent to fit. Furthermore, these two

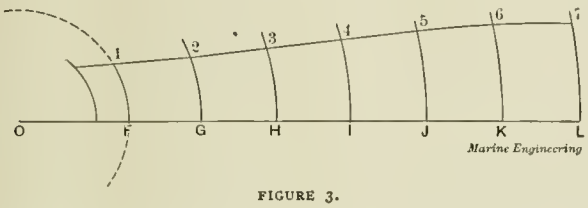


FIGURE 3.

guides should be so located that a radius of the propeller, as $O\,R$, Fig. 8, drawn from say the mid height of the inner hub guide, will just rest on the outer guide, also at its mid height.

(12) Where the lift would then come in contact with the outer guide at radius $O\,K$, Fig. 1, it should be beveled on the straight or blade face edge until it is brought to the angle determined by the guide, and with the upper angle of the straight edge just resting on the guide.

(13) In similar manner the successive lifts should be fitted and secured in place in the hub, and to each other likewise, by glue and nailing, care being taken with the latter to avoid locating nails where they may interfere with the later work of reducing to finished form. There will thus result a step-formed block of which a beveled line at the hub will lie along the line of intersection of blade surface and hub, while a similar line near the tip will lie on the guide corresponding to radius $O\,K$, and will therefore give the finished surface on a line across the blade at this radius.

(14) It follows that the lines determined by the inner angles of the steps on the straight side will all lie on the final helicoidal surface of the blade, and it therefore remains only to remove the projecting angles and bring the entire driving face just down to the lines determined by these inner angles. The fact that the lines determined by these angles lie on a helicoidal surface results from the definition of such a surface, and must be accepted here without further mathematical proof.

(15) The developed contour of the blade as given in Fig. 1 is then laid off on the blade surface, reckoning from the center

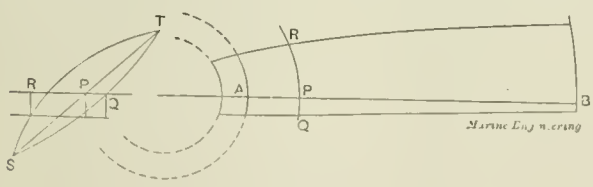


FIGURE 4.

line $O\,L$ laid off on the pattern from hub to tip. The part outside this contour being then removed, the final contour of the blade remains.

(16) It is readily seen from the manner in which the widths of the lifts have been determined, that the form of the back of the blade will also be determined by removing the outer angles of the lifts on the curved or back edge, and reducing the surface just down to the lines determined by the inner angles on the back or thickness side of the pattern. These indications will not be definite near the boundary of the blade, and for the finished angle at the edge of the blade it is best to have a separate gauge made by setting an ordinary bevel gauge at the general edge angle for the outer or thinner parts of the blade and supplemented by other special gauges for the angles at the thicker parts of the blade. These various angles may be taken from the drawings, and for the thin part of the blade may vary from 8 or 10 degrees for bronze to 20 or 30 degrees for cast iron.

With such gauges for the edge and the guide given by the inner angles of the step-wise pattern, the form of the back may be very satisfactorily worked out. After determination in this general manner the thickness layout may then be tested by calipering and comparing with the drawing board layout as given by the sections of Fig. 1.

(17) The hub may next be worked down on front and rear ends and given such form of taper or curve as the design may call for.

The angles where the blade and hub are joined must be well filleted. This may be effected by cutting and putting in the fillets after the surfaces of the blade are brought to form. If desired, however, the fillet for the back may be readily formed in place from stock provided for that purpose, but for the face side it will be better to cut and fit the fillet separately.

(18) The final details of smoothing and finishing the pattern for use in the foundry may then be carried out in the usual manner for operations of this character.

Should it be desired to place a part of the thickness on both sides of the fundamental geometrical surface, as is sometimes the case, the blade pattern lifts must be modified accordingly.

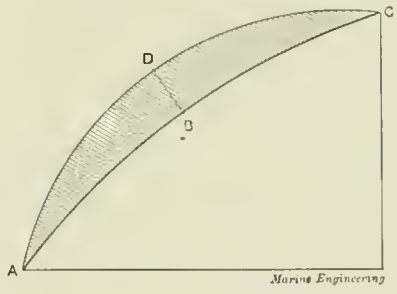


FIGURE 5.

The blade sections will give the layout desired as indicated by the section of Fig. 4. The point P would lie on the ideal geometrical surface, of which the line $S\,T$ denotes the developed guide for the location of this particular section. A line $A\,B$ on the blade lift is then drawn to denote the radial line which is supposed to be seen end on at P. The distance $P\,R$ is then laid off on one side of $A\,B$ and $P\,Q$ on the other, and similarly for all the other inclined sections, thus giving a thickness distribution on both sides of the line $A\,B$. It is seen that this is equivalent to starting with an ideal surface determined, as above described, by $A\,B$ and other straight lines similar thereto, and then laying out in the manner described in (8) to (16) above, a certain distribution of thickness on each side of such foundation surface. With these general hints no trouble should be experienced in laying out any distribution of thickness which may be desired.

In case the blades are to tip or rake back instead of standing at right angles with the shaft, it will be necessary to correspondingly tip or incline the lifts of the blade pattern down from the hub outward, for a pattern made face down. In such case the same general methods are to be followed as already described, with the substitution of the inclined angle for the blade lifts. With due attention to the principles involved in the operations above described, no difficulty will be found in thus adapting them to the case of a pattern for blades inclined back from the perpendicular.

Should it be desired to make a pattern for the propeller complete, so that it may be molded entire in one operation, it is only necessary to repeat for each blade the same general process outlined above, locating the blade patterns, three or four in number, at the proper points about the circumference.

If the propeller is to be made with separable blades, then the hub and blade patterns are made and cast separately. Details for the hub pattern will be given by the drawing, and its construction will present no special difficulties. The blade pattern may be made in the same general manner as above described, except that at the inner end it is attached to a boss or flange instead of a hub. The pattern for the boss, which is usually spherical on the outer surface, may be made separately and then set up in position on the surface board. The guides corresponding to hub and tip as previously described may then be prepared and set up in similar manner, the inner one just touching the boss pattern at the extremity of its spherical form. A light straight rod may then be placed on both guides, levelled up and moved up and down the guides, being kept horizontal or levelled up in the meantime. The inner end of this rod being carried into contact with the boss will then trace thereon a line which will give the intersection of the blade surface with the boss, and which will serve as a guide for the groove into which the lifts of the blade pattern are to be secured.

If it be desired to form the boss of the same pieces as the blade pattern, then sufficient stock must be left on the lifts as shown by the sections of the boss, and the lifts are then to be simply lined up and adjusted with reference to the two guides set up as before. The lifts being then glued and nailed together, the boss may be formed up in accordance with the dimensions shown by the drawing, and for which provision has been made in the extra stock left on the inner ends of the lifts.

In small propeller patterns it may be desired to form the hub together with the blade. In such case it is only necessary to saw out circular sections of the hub with each lift, and to mount them as above described, the collection of hub sections thus forming the hub pattern as a whole.

In case the propeller is not of uniform pitch from leading to following edge, the developed guides will have the hypotenuse, *P F* or *P K*, Fig. 1, curved instead of straight. In such propellers the pitch usually increases from leading to following edge, thus rendering the face of the blade hollowing or concave and the corresponding guide convex as indicated in Fig. 5.

When the propeller is to have different values of the pitch from hub to tip, and especially if the distribution of pitch is generally irregular, it may be preferred to modify the general procedure outlined above, and to determine the driving surface of the blade by means of a number of guides each giving the slope suitable for its location on the blade, and without reference to radial lines determined by the inner angles of the blade pattern lifts as before.

To this end the process may be carried out as follows:

(1) A series of lifts is prepared, of sufficient width to insure stock for blade thickness, but without attempt to lay out such width from the sections as before.

(2) These lifts are then glued and nailed up in general slope to correspond with the mean or average value of the pitch, but without any attempt in this part of the process to fit them accurately to any of the guides.

(3) Prepare the hub pattern and hub guide and lay out and cut groove as in (3), (4) and (5) of the preceding method. Then trim inner end of blade pattern to fit groove, and secure in place as previously described.

(4) A series of guides is then prepared, corresponding to successive locations from hub to tip, and each one having the form suitable for the distribution of pitch at that particular distance from the center of the hub.

(5) Marks must then be established so that when these guides are lined up along some reference line on the surface board, the various guide lines similar to *P F, P G, P H*, etc., Fig. 1, will all correspond in height, and will therefore lie on the surface of the blade as designed.

(6) One of the guides is then located on the circle and adjusted to its reference mark, and the blade and hub are swung on the center or propeller axis until the blade pattern comes in contact with the guide. Inspection of the two will show how the blade is to be pared down in a line across the block in order to bring it into contact with the guide. This process of paring and fitting must then be carried on until the block is brought to a satisfactory fit with the guide, while at the same time the block as a whole is brought around to some definite and selected position on the board indicated by witness marks on block and board, such position being chosen by judgment in such manner as to insure sufficient stock at all parts of the blade for bringing the pattern down to a fit with the corresponding guide. The next guide is then set up in its place and adjusted to its reference mark and the block brought around and pared across until ultimately when brought to the blade witness mark it will show full contact with its guide across this part of the blade. The remaining guides are set up and the operation is carried through in the same manner for each, at the end of which series of operations there will result a series of grooves across the blade, the bottoms of which will in each case lie in the surface of the blade as designed. It only remains therefore to take down the intermediate high parts and gradually bring the face to a smooth and continuous surface, just containing the bottoms of the grooves as determined from the guides, and which may be conveniently marked by colored crayon in order that they may be more easily identified when bringing the surface down to its final form.

(7) The back is then smoothed off likewise in bands across the blade, and is given a thickness layout as determined by caliper and corresponding to the sections given by the drawing, as in Fig. 1.

Some pattern makers would prefer to follow this latter general plan in making all patterns, whether for variable or uniform pitch. In the latter case the developed guides are all triangles with straight line hypotenuse as in Fig. 1, and each is bent up and located as described. The general process thus amounts to a determination of the finished surface by means of a series of lines across the blade, each brought down to fit a corresponding guide, and the high parts being then removed to form a smooth and continuous surface; while in the other case the form is determined by means of a series of straight radial lines resting on two guides, as above, the high parts or angles being then removed to form a smooth and continuous surface as before. Both methods are geometrically correct and with proper care both will give the same final result for a given pattern. As a rule, however, the first method may be recommended for propellers of uniform pitch, or where the pitch does not vary radially, while the latter method will be found more practicable for radially varying or other complicated distributions of the pitch.

The pattern indicated in the sketches is laid out face down. This again is a matter of choice, and some pattern makers prefer to make it face up, especially when following the second general method as above described. The differences in the two methods are found however only in the details, and with a good understanding of the principles involved, no trouble should be met with in carrying out the process with the pattern either side up on the surface board.

SWEPT UP MOLDS.

Turning now to the swept up mold, the principal steps in the process may be indicated as follows:

(1) Prepare a smooth level foundation of sufficient size to accommodate the entire propeller, and with some 6 to 10 inches extra outside the tips of the blades.

(2) In the center of this floor set up a vertical iron post—usually a piece of shafting—and secure the same at the top to give perfect steadiness to the sweep arm which it is to carry.

(3) Make sweeps for the hub and for the foundation as indicated in Fig. 6. Then sweep up the hub in the usual manner over a brick work core, and level up the foundation with the sweep prepared for that purpose. The outer end of the sweep at *A* will produce a bed for the guide, and the central part at *B* a slightly raised bed for the hub. In some cases the hub pattern is made in wood and set in place, instead of sweeping it up out of loam.

(4) Prepare the blade sweep, the entire arrangement being assembled and adjusted somewhat as in Fig. 7. The edge of the board should be brought down nearly sharp at one angle as at *a*, and if desired may be shod with metal to insure against wear. The length *C D* should be sufficient to bring the point *D* some 6 or 8 inches beyond the tip of the blade.

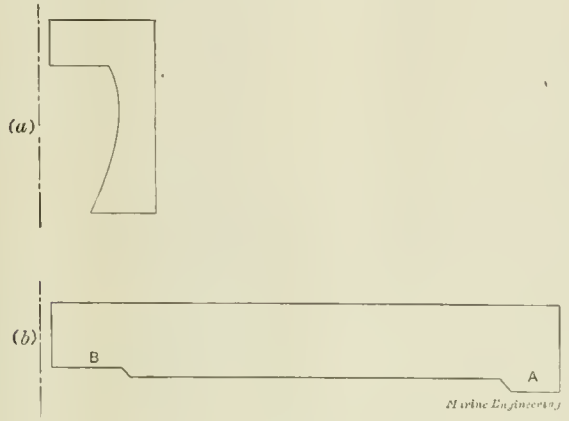


FIGURE 6.

(5) Prepare a "guide iron" similar in form to those described in connection with the construction of a pattern in wood, but corresponding to a radial distance about 6 inches beyond the tips of the blades, in order to allow for the joint of the mold, and as represented in Fig. 1 by the triangle *P O L*. This "guide iron," so called, may be made either of sheet metal—thin boiler or ship plate usually—or of wood and shod with metal on the upper or guide edge. The construction in wood may be carried out as follows:

In Fig. 8 (a), let the curved contour denote the form of the blade projected on a transverse plane, or as seen from aft looking forward. Draw two radial lines as shown, thus comprising between them the entire face of the blade. Continue these to a distance of about 6 inches beyond the tip of the blade, and draw the arc *P Q*. Then prepare a block of wood of length *A B* and breadth *B C* as shown, and of height slightly greater than the greatest projected longitudinal dimension of the blade *R S* (b). Lay out on this block the curved strip *P Q* as shown in Fig. 9, and of mean radius the same as that of *P Q*, Fig. 8, and cut it out with band saw, thus giving a sector of a cylindrical shell of one to two inches thickness. Then cut out of sheet iron or heavy paper a triangle similar to *O P L*, Fig. 1, and of dimension *O L* not less than *P Q*, and fold it about the shell *P Q*, the side

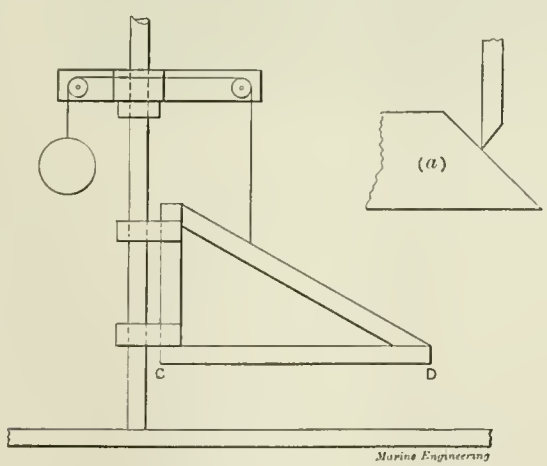


FIGURE 7.

O L along the base and *O P* vertically. Mark on the convex side of *P Q* the line along the hypotenuse *P L* and cut the shell down to this line, and the guide is ready for use. If desired it may be protected with sheet metal on the inclined or guide edge.

(6) Set up the guide on the foundation at the proper radius and between iron pegs driven into the sand to hold it in position. Care must be taken to adjust the height of the guide to correspond with that of the hub. If then the sweep edge is brought down into contact with the guide and the sweep is so moved as to keep the edge constantly in contact with the guide, the edge will describe the exact helicoidal surface which it is desired to give to the blade.

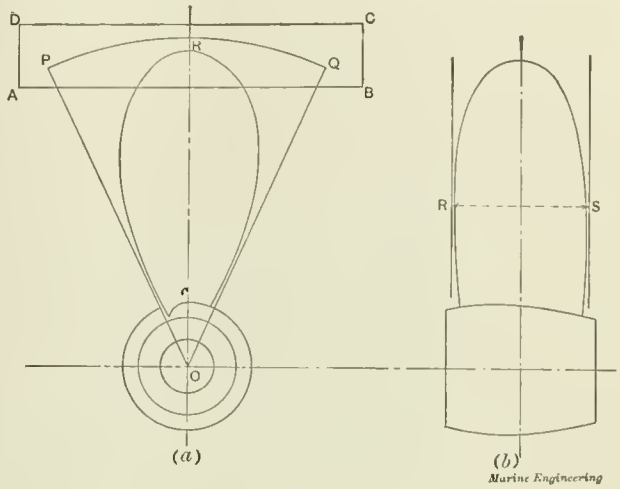


FIGURE 8.

(7) Prepare a sloping foundation of brick-work between the hub and guide and of the general slope which the blade surface will show, keeping the same a few inches below the finished surface as indicated by the location of the sweep edge *C D*, Fig. 7, when moved up and down in contact with the guide.

(8) Spread loam on this blade foundation and then follow up and down with the sweep, smoothing off and packing up until a smooth continuous surface of loam is thus developed. This represents the face side or surface of the blade.

(9) Lay out on this surface the blade center line, corresponding to *O L*, Fig. 1, and from this line lay out the blade contour full size on the loam from the dimensions taken from the drawing.

(10) Brad points inserted in the sweep edge at points corresponding to the location of the blade sections of Fig. 1 will trace in the loam surface lines showing the location of the full sized blade thickness strips. These are to be sawn out of about 7/8 inch stock, and in form as given by the blade sections of Fig. 1, and then saw-kerfed in lines perpendicular to the blade surface, so that they may be bent to follow the lines drawn in the loam by the brad points. These thickness strips may then be secured in place each on its own line by brads or thin nails pushed into the loam.

(11) The loam surface is then treated with parting sand and the spaces between the thickness strip filled in with molding

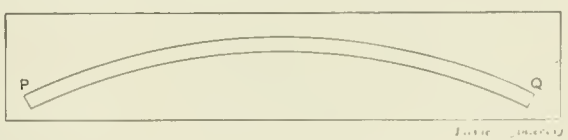


FIGURE 9.

sand and smoothed off on top to a continuous surface, thus forming the rounded back of the blade.

(12) This is next treated with parting sand and the cope of the mold is put in place, filled, and rammed up in the usual manner. Great care must be taken in ramming not to disturb or injure the blade pattern in sand.

(13) These same general operations are repeated for each blade of the propeller, three or four in number about the circumference, and also for the hub.

(14) The blade copes are then lifted off, carrying each one the reverse form of the back of a blade. The blade patterns in

sand are then removed and destroyed, leaving the original helicoidal surface as generated by the sweep.

(15) The hub is next removed similarly, and the copes are

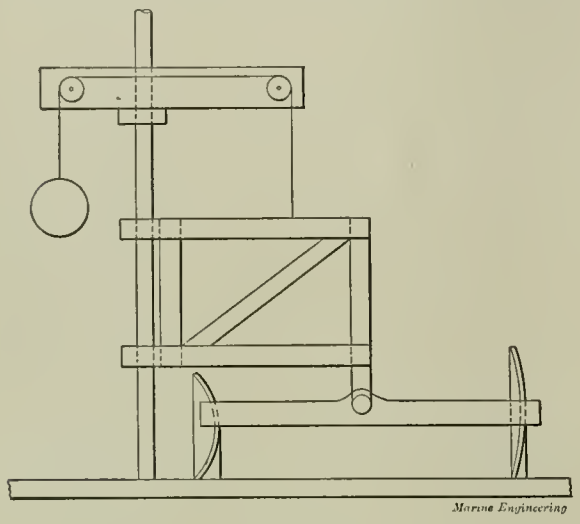


FIGURE 10.

then returned in place; and with the upper and lower parts of the mold together the form of the propeller complete is left as a cavity to be filled with the molten metal.

Many minor steps are omitted in the above brief description, but with a general knowledge of foundry methods and principles, and a careful study of the operations noted above, no serious trouble should be met with in sweeping up the mold for a propeller of uniform pitch and with blades perpendicular to the axis.

If the propeller is of moderate size a single cope may be employed for the entire propeller instead of one for each blade and the hub. Where adequate provision is at hand for lifting and handling heavy copes, such method would usually be preferred in any case.

If the blades are to be tipped back from the perpendicular the sweep edge must be correspondingly tipped down from the post outward. Otherwise the general operations are the same as for straight perpendicular blades.

In case the pitch is expanding—that is, increasing from entering to following edge—the developed form of the guide hypotenuse will be rounded or convex instead of straight. Otherwise the operations are the same as above.

When the pitch is to vary radially two guides must be employed, one at the hub and the other at or beyond the tip, while the sweep must be pivoted on an arm carried as indicated in Fig. 10.

In case the thickness is not all placed on the back of the blade or on one side of the geometrical surface developed by the sweep as above, then the guides must be modified accordingly and as determined by trial, until the desired distribution of thickness is obtained. Such a distribution of thickness, partly on the driving face, results really in a modification of the face pitch; substituting for a uniform or simple variation, a complex and possibly extreme variation, as determined by the actual resulting surface of the driving face.

A NOTABLE ELLERMAN LINER.

BY BENJAMIN TAYLOR.

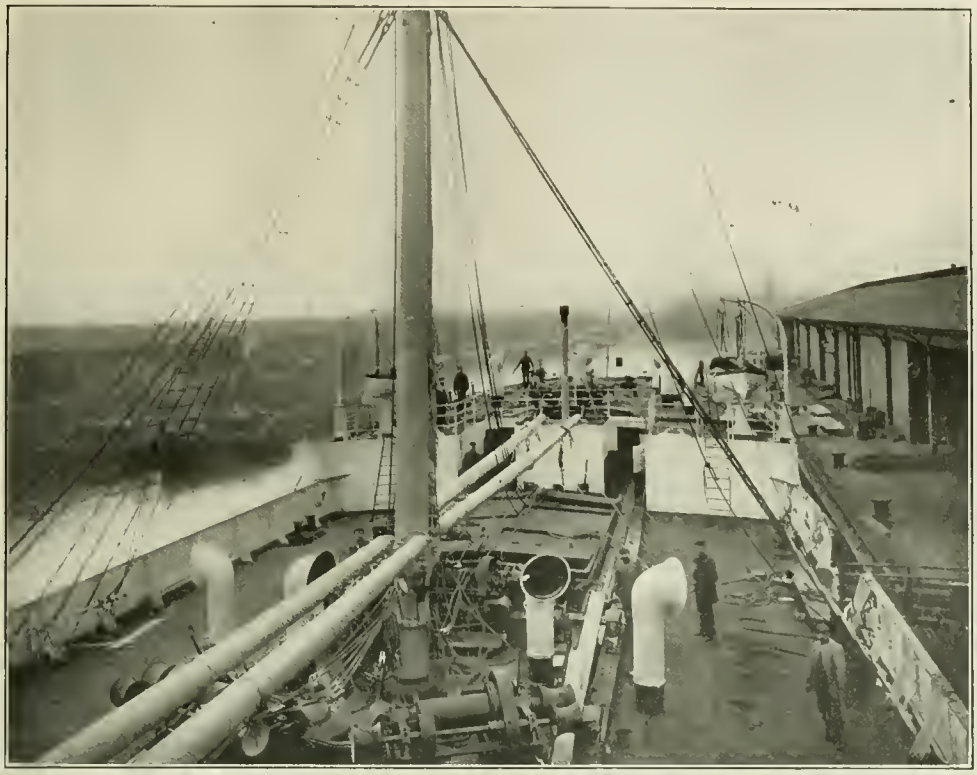
One of the most striking developments in the British shipping industry of recent years has been the combination now known as The Ellerman Lines, Limited. Originated by Mr. J. R. Ellerman, Liverpool, it owns now not only the "Ellerman" steamers whose names all terminate with "ian," but it has acquired the "Hall" Line of Liverpool, and the historic "City" Line of Messrs. George Smith and Sons, Glasgow. This progressive concern now owns no less than 80 steamers, aggregating 175,000 tons, and in order to open up new services and increase old ones it has at present some 37,000 tons of new tonnage under construction.

THE NEW ELLERMAN LINE STEAMER TRAFFORD HALL.

One of the latest additions to this fleet is the steamer of which we present photographs, the *Trafford Hall,* which was built by Messrs. Barclay, Curle and Company (Limited), Glasgow, and which has just taken her place on the Indian service of the lines. The expansion in trade between Great Britain and India has rendered it necessary to make a considerable addition to the fleet. The same builders have still three vessels of a similar type in hand for the owners. During the past fifty-seven years these builders have constructed for the Ellermans thirty-five vessels, with a total tonnage of 68,141 tons.

In some respects the *Trafford Hall* is unique. She is the largest steamer of the Ellerman fleet, and she has the largest passenger accommodation of any vessel trading between Glasgow and Liverpool and Indian ports. She was built to the classification of the British Corporation Registry.

The *Trafford Hall* was designed for a sea speed of 11½ knots, but on trial runs a mean speed of fourteen knots was maintained.



VIEW LOOKING FORWARD FROM NAVIGATING BRIDGE.

She was specially designed for a new monthly express passenger service from Liverpool to Egypt, Bombay and Karachi. The average passage to Port Said is to be in ten and a half days, and to Bombay in twenty-one days, canal excluded. Accommodation is provided for 100 first class passengers.

The dimensions are:

Length over all	410 feet
Breadth	50 feet
Depth from top of upper deck at centre	32 feet 7 inches
Gross registered tonnage about	5,500 tons

THE TRAFFORD HALL, LOOKING AFT FROM STARBOARD BOW.

The steel hull is divided into watertight compartments and a complete inner bottom is fitted fore and aft, which, besides insuring safety in the event of grounding, allows the trim and draft to be adjusted to suit different conditions of service. Poop, bridge and forecastle are built on the upper deck; the bridge forms the lower promenade for first class passengers, and above this are the upper promenade deck, lower and upper navigating bridge decks.

clusters for use when discharging cargo at night. Awnings are fitted fore and aft and six lifeboats placed where they can be rapidly put into the water when required.

The machinery consists of triple expansion engines supplied with steam from three large boilers, with a working pressure of 215 pounds. The boilers are fitted with Howden's forced draught and with superheater. The outfit of auxiliary machinery includes large condensers for renewing the supply of fresh water.

FIRST CABIN DINING SALOON ON NEW ELLERMAN LINER.

The passengers are berthed amidships and the sleeping cabins are on the upper bridge and promenade decks. These cabins are large and well ventilated, and several of them are convertible into double rooms. A nursery is provided for children.

The dining saloon is a spacious apartment at the fore end of the bridge deck, and extends the full breadth of the ship. It is well lighted and ventilated, having large windows on three sides, and a dome skylight overhead. It is panelled in light oak. Adjacent to it is the main staircase, giving access to the music room and to the deck cabins on the promenade deck. The music room is panelled in lincrusta with mahogany framing, and is well lighted by cottage windows. At the after end of the promenade deck is the smoking room, a large and lofty apartment, panelled in oak, with lincrusta panels in the ceiling.

Ample sanitary accommodation is provided, fitted in different parts so as to be equally accessible from any cabin. The baths are fitted with hot and cold water and with douches, and patent heaters are provided on each bath. The dining saloon, music room, smoke room and all state rooms have electrically driven fans, which can be regulated to three speeds, for purifying the air.

The chief galley is on the bridge deck, between the engine and boiler casings, with bakery adjoining. It is fitted with all the latest appliances for cooking. Refrigerating chambers carry the stores for the passengers' consumption.

The officers' and engineers' accommodation is on the after end of the bridge deck. A large chart room and wheelhouse contain the steering wheel and other navigating appliances. The seamen, firemen, stewards and petty officers occupy the poop and forecastle.

The appliances for loading and discharging cargo are very complete. There are five cargo hatches of large size, with ten derricks and nine powerful winches. The vessel is lighted throughout by electricity, including navigating lights and large

Progress of Naval Vessels.

The Bureau of Construction and Repair, Navy Department, report under date of April 10, 1906, the following percentage of completion of vessels building for the United States Navy:

			Mar. 1.	Apr. 1
BATTLESHIPS.				
Virginia	19 knots.	Newport News Co.	99.	99.5
Nebraska	19 "	Moran Brothers Co.	90.	92.
Georgia	19 "	Bath Iron Works	94.59	95.75
New Jersey	19 "	Fore River Shipbuilding Co.	97.5	98.5
Connecticut	18 "	Navy Yard, New York, N. Y.	96.13	97.11
Louisiana	18 "	Newport News Co.	97.19	97.92
Vermont	18 "	Fore River Shipbuilding Co.	76.3	79.3
Kansas	18 "	New York Shipbuilding Co.	74.2	75.7
Minnesota	18 "	Newport News Co.	83.52	85.27
Mississippi	17 "	Wm. Cramp & Sons	51.21	52.84
Idaho	17 "	Wm. Cramp & Sons	49.18	51.44
New Hampshire	18 "	New York Shipbuilding Co.	39.3	40.4
"ARMORED" CRUISERS.				
California	22 knots.	Union Iron Works	90.	91.9
South Dakota	22 "	Union Iron Works	89.1	89.8
Tennessee	22 "	Wm. Cramp & Sons	94.53	96.37
Washington	22 "	New York Shipbuilding Co.	95.5	96.
North Carolina	22 "	Newport News Co.	37.04	39.97
Montana	22 "	Newport News Co.	32.41	35.4
SEMI-ARMORED CRUISERS.				
St. Louis	22 knots.	Neafie & Levy Co.	90.56	93.37
Milwaukee	22 "	Union Iron Works	90.9	92.5
SCOUT CRUISERS.				
Chester	24 knots.	Bath Iron Works	22.28	26.15
Birmingham	24 "	Fore River Shipbuilding Co.	24.5	28.6
Salem	24 "	Fore River Shipbuilding Co.	24.9	28.9
SUBMARINE TORPEDO BOATS.				
Submarine No. 9		Fore River Shipbuilding Co.	61.	63.9
" " 10		Fore River Shipbuilding Co.	48.9	52.5
" " 11		Fore River Shipbuilding Co	50.9	58.2
" " 12		Fore River Shipbuilding Co	48.3	51.4

THE HENDRICK HUDSON.

Promptly at three o'clock, March 31, the new Albany Day Line steamer *Hendrick Hudson* was launched in the yard of the Thomas S. Marvel Shipbuilding Company at Newburgh, N. Y. This steamer, which is said to be the largest river steamer in the world, is being constructed to accommodate the greatly increasing passenger traffic upon the Hudson, the present day boats being now crowded during the season almost to their full capacity, and in some cases being called upon to transport more people than they can comfortably carry. The Hudson river has long been noted for the magnificent scenery which lines its banks for a hundred miles of its course above the city of New York, the diversity being unequaled, not only in this country but anywhere else on the globe; and it is to afford opportunities for visitors to see this spectacle that the new steamer will be put into service.

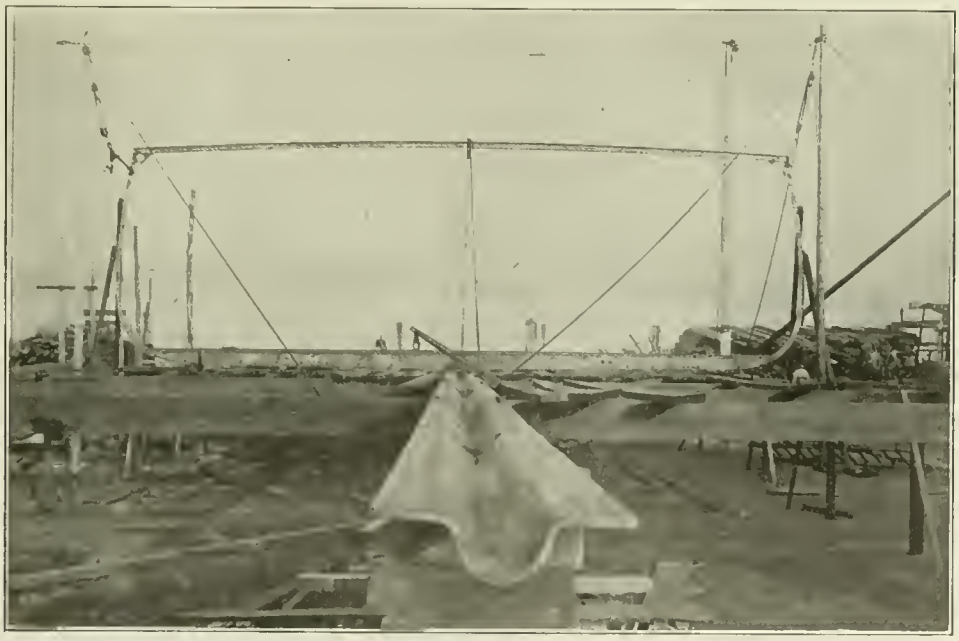
The *Hendrick Hudson* has a length over all of 402 feet; a water line length of 390 feet; an extreme beam of hull amidships of 43 feet; a maximum beam over the guards of 82 feet; a depth of hold of 14 feet 4 inches; and a uniform draft of 8 feet throughout the straight portion of the keel. The forefoot is largely cut away, and as our illustration shows, the deadwood at the stern is likewise cut away, allowing the fitting of balanced rudder overhanging the after end of the keel. The contract for the construction of this steamer was placed with the W. & A. Fletcher Company of Hoboken, who are building the boilers and machinery. It is under a sub-contract that the hull has been built, while another sub-contract covering the joiner work has been let to John Englis & Sons, of Greenpoint, Brooklyn.

The hull is constructed entirely of steel, while a rigid frame work of the same material acts as a support of the joiner work in the upper part of the boat. This frame work is so designed as to act as a steel girder or truss, thus making it possible to do away with the ungainly hog masts so prominent in the older constructions. Seven steel watertight bulkheads render the vessel practically unsinkable, while all the inclosures around the boiler and machinery spaces are built up of heavy steel plating, thus eliminating practically all danger of fire.

As the engine, which is of inclined three cylinder short stroke pattern, is made direct acting, there will be no walking beam. Another innovation will be the placing of the paddle wheel shaft below the deck, this being made possible by the adoption of paddle wheels of small diameter. This feature will obviate the necessity of dodging under the shaft or climbing over it, as is the case with most of the boats now in service.

In general arrangement, it will be seen from the drawing that there are five decks, of which three are given up wholly to passengers' accommodations, while two of the others are partially so utilized. The bridge deck contains simply the pilot house, and is not available for passengers. The shade deck contains two short deck houses occupied by officers' quarters, the balance of the deck being an open promenade. The promenade deck has large open spaces at bow and stern, together with a narrow passageway along both sides of the boat connecting these two. The remainder of space, occupying nearly two-thirds the length of the boat, consists in two large observation rooms, one forward and one aft, with a narrow portion devoted to the use of firemen and to a light and ventilating trunk between the funnels. Just abaft the after funnel is an open passageway across the deck. The saloon deck has about the same arrangement as the promenade deck, except that, being below the latter, the promenades at bow and stern are covered instead of being open. The main deck has a forward promenade similar to that on the saloon deck, aft of which is an inclosed compartment for passengers, followed by the engine inclosure, a small trimming tank, the boiler inclosure, purser's office, and the large dining room. The lower deck has forward the crew's quarters, immediately in rear of which are the bar room and the lunch room. Then comes the engine room, extending over a length of 62 feet. The boiler compartment covers a length of 74 feet, the coal being stored in wing apartments on either side. Next come galley, serving room and quarters for waiters. There is space below the galley and waiters' quarters aft, as well as below the bar and lunch room forward, for the stowage of stores. No freight whatever will be carried, as the entire space is taken up by accommodations for passengers, etc.; and the weight is likewise entirely allotted to this same purpose.

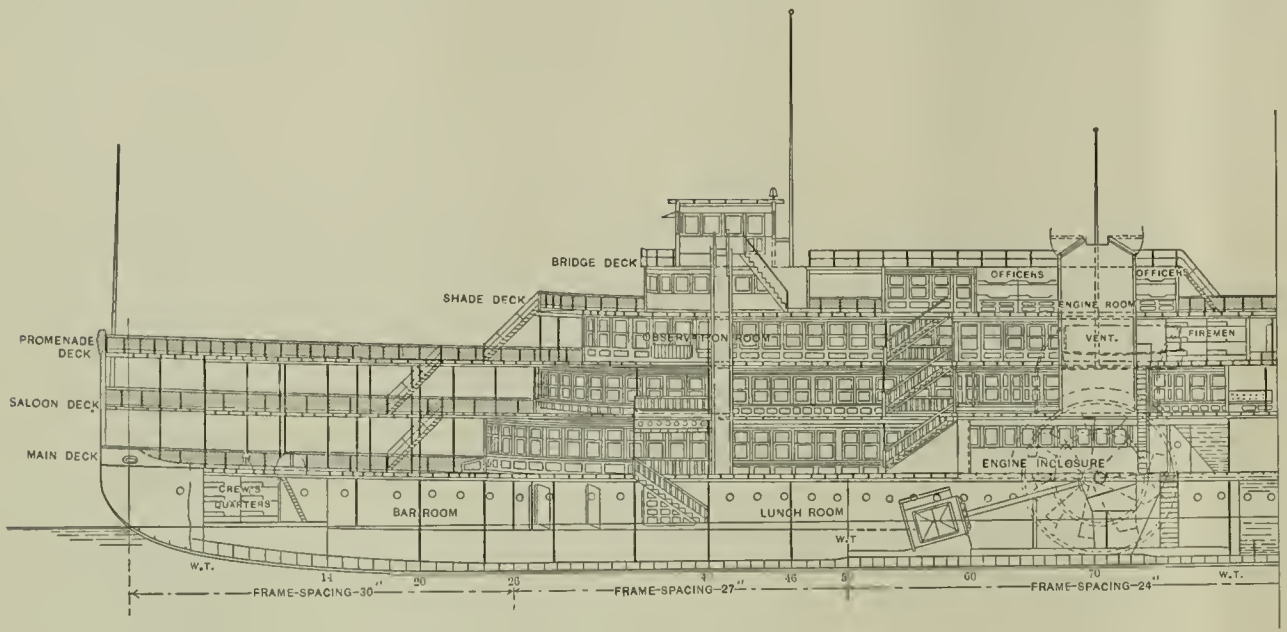
The observation rooms on the promenade deck are fitted all around with plate glass windows, affording a magnificent outlook



THE FIRST FRAME IN POSITION, SEPTEMBER 27, 1905. GUTTER KEEL ALSO SHOWN.
(Our photographs are from D. E. Herrick, Newburgh.)

in all directions, while the other inclosed portions of the decks have similar arrangements for observation. A band plat-

The frames are spaced 24, 27 and 30 inches apart, as mentioned above. The only exception to this regular spacing is



BOW:—LONGITUDINAL SECTION OF THE HENDRICK HUDSON.

form will be suspended in an opening in the saloon deck forward in such a way that the music will be audible on the promenade, saloon and main decks. It is estimated that 3,000 passengers can sit within hearing of the orchestra without crowding. The carrying capacity of the steamer is placed at 5,000 passengers. The speed is 23 miles per hour.

THE SCANTLINGS.

The stem down to the 4-foot water line is a rolled bar of iron measuring 6 by 2 inches; the balance down to the keel measures 4½ by 1½ inches, and has a connection to the keel

forward of the collision bulkhead, on frame No. 6, where the 30-inch spaces are sub-divided by intermediate frames into 15-inch spaces. The frames are all of bulb angles measuring 4 by 2½ inches by 8 pounds per running foot, and extend in each case in one length from keel to main deck stringer plate. For a distance of 175 feet amidships doublings of the same scantling and 24 inches long are fitted across the keel, and riveted through the floors to the frames. This connection at the ends of the vessel is made by allowing the frames to lap over the center, where they are riveted to each other. At

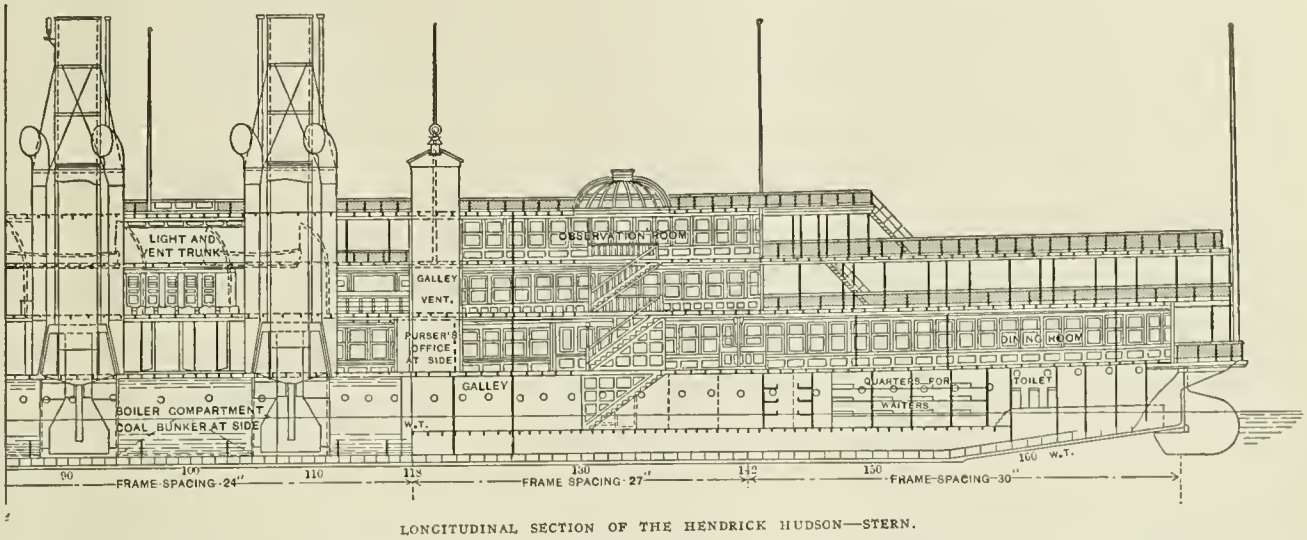
EXTERIOR VIEW OF BOW FRAMING, WITH SOME PLATING IN PLACE, DECEMBER 14, 1905.

plate 36 inches long; the stern post is of hammered iron measuring 6 by 4½ inches at the keel and 6 by 7½ inches at the tuck. The head of the post is secured to an 18-pound transom plate. The inclined portion of the keel, between the rudder post and the flat keel, measures 4½ by 1½ inches, and has a 36-inch connection with the keel proper. At the heel of the post is a step for the rudder. The keel proper is of the hollow or gutter type, consisting of a plate of flanged steel 20 inches wide and weighing 22 pounds per square foot, with a 4-inch gutter. The plates are fitted in long lengths, with 22-pound treble riveted butt straps.

watertight bulkheads the frames measure 5 by 3 inches by 9 pounds, while abaft the stern post the size is 3½ by 2½ inches by 6 pounds. Reverse frames are fitted only under the engine and boiler spaces, and extend in a single length entirely across the vessel. In the engine room they measure 3 by 3 inches by 7 pounds, and in the boiler room 2½ by 2½ inches by 5 pounds.

The floor plates are 15 inches deep at the center line, except in the engine space, where they are 20 inches deep. In the engine and boiler space they measure 15 pounds per square foot; in the 27-inch frame spacing, 12 pounds; and at the ends of the vessel, 10 pounds. They are worked in one piece across

the vessel except in way of web frames. The tops of floors are flanged 3 inches. Limber holes 3 inches in diameter are placed as low in them as possible. At bulkheads the floors are 15 pounds thick and 27 inches deep, while at the ends the depth is increased.



LONGITUDINAL SECTION OF THE HENDRICK HUDSON—STERN.

At frames 83, 87, 96, 103, 112 and 116 the floors are made sufficiently high to be used as boiler saddles. They are fitted here with double 3 by 3-inch by 7-pound angles on top, and with knee plate braces.

Web frames are spaced every six or seven frames throughout the length, and are formed of 10-pound plate 15 inches wide, riveted to the main frames and carrying on the inner edge two 2½ by 2½-inch by 5-pound reverse frames worked continuously across the tops of the floors and up to the deck. At the wheel beams and sponsons three of these web frames are fitted, of 13-pound plate, with double 3 by 3-inch by 7-pound angles on inner edge. The keelsons do not cut the web frame angles, but are carried over them, and fitted with diamond plates.

On each side of center line amidships three keelsons are worked over the floors. Fore and aft of machinery space the center ones unite into a single keelson. They consist of a 5-inch by 12.5-pound Z-bar, a continuous 3 by 3-inch by 7-pound angle and 10-pound intercostal flanged plates to the shell. Connections are made with the floor by clips consisting of 2½ by 2½-inch by 5-pound angles. There are also fitted on each side one bilge stringer and one side stringer, of the same construction as the keelsons, except that the continuous angle in this case is omitted fore and aft of the machinery space. All keelsons unite at the ends of vessel with breast hooks. The side keelsons between wheel beams are 36 inches wide, with double 2½ by 2½-inch by 5-pound angles on the inner edge, and are fitted with diamond plates at web frames. All keelson bars are carried continuously through the transverse watertight bulkheads, and have watertight gravets fitted around them.

THE FORWARD FRAMING AS IT APPEARED DECEMBER 28, 1905

Deck beams are placed on every frame, and fitted in one length from side to side of hull. They measure 5 by 2½ inches by 10 pounds, bulb angles, for the 24-inch frame spacing; 4 by 2½-inch by 8-pound bulb angles for 27-inch frame spacing; and 3½ by 2½-inch by 6-pound angles at the ends. They are connected to the frames by 12-pound bracket

plates, reduced to 10 pounds for the 3½-inch beams, and extending 18 inches on the frame and 16 inches on the beam. At each end of wheel opening and across the boiler hatch are fitted strong beams. Where the deck beams are cut in way of main deck hatchways a fore-and-aft piece of same scantling as the beam is fitted. Fore and aft of machinery space are hold beams, angles, 3½ by 2½ inches by 6 pounds, on every third frame. Under the galley and forecastle are fitted 10-pound knee plates on every frame. The crown of deck beams is 16 inches in 82 feet.

The shell plates are joggled, with in-and-out strakes, and fitted with butt straps, each plate being more than 18 feet long. The garboard strake measures 18 pounds between frames 25 and 150, and 16 pounds at ends. The sheer strake, which is 33 inches wide, measures 27½ pounds for the half length amidships, and is gradually reduced to 11 pounds at the ends. In way of the wheels, the sheer strake is fitted with a 15-pound doubling plate. The other bottom and side plating for 100 feet amidships weighs 15 pounds per square foot; for a further 70 feet forward and 70 feet aft it is 13 pounds, while the ends are 11 pounds thick. The longitudinal laps of all sheel plate are single riveted except that the garboard connection to the keel and the connection of the sheer strake to that next below it are double riveted. The butts of garboard strake are treble riveted; those of the sheer strake, double strapped and treble riveted for 100 feet amidships double strapped and double riveted for an additional 100 feet at each end, and single strapped and double riveted at the ends. The butts of the bilge strake are treble riveted for 75 feet amidships. All other shell butts are double riveted.

The main deck stringer plate is 36 inches wide and measures 21 pounds for 200 feet amidships. It is gradually reduced at the ends to 30 inches by 11 pounds. Other deck plates are fitted at the wheel opening. The butts of the stringer plates are double riveted, with double straps. The harpin is 3 by 3 inches by 10 pounds, reduced gradually to 8½ and 7-pound angles. Center and side tie plates are 9 inches wide, and fitted in long lengths of 12-pound plate, with butts lapped and treble riveted. Forward of collision bulkhead and aft of frame 168 the deck is completely plated with 10-pound steel, as is also the case on the guards aft of wheels for a space of about 200 square feet on each side of vessel. In this latter case it is stiffened with angles. The lower deck beams under galley are covered with 8-pound plates.

There are seven athwartship steel watertight bulkheads. The collision bulkheads are of 12-pound plate stiffened by vertical angle bars 3½ by 2½ inches by 6 pounds, spaced 24 inches apart, and horizontal bulb angles on opposite side spaced 4 feet 6 inches apart, and measuring 4 by 2½ inches by 8 pounds. The horizontal bars are bracketed to the shell. The other athwartship bulkheads, except at frame 71, are of 11-pound plates worked vertically with 4-inch flanged edges, measuring 2 feet 6 inches between flanges, and with horizontal angle bulbs, 4 by 2½ inches by 8 pounds, 4 feet apart, on other side, connected to shell plating by gussets. The bulkheads are connected to skin plating by 5 by 3-inch by 9-pound angles with double zigzag riveting. Each bulkhead is fitted with a brass sluice valve of about 20 square inches opening, operated from main deck. Sounding tubes are fitted in each watertight compartment.

The guard beams are straight, and are carried out from the hull on a line tangent to the crown of main deck beams. They are 5 by 3 by 3 inches by 11.2 pounds Z-bars, fitted on alternate frames, and with bracket plates to hull; the latter are 21 by 16 inches by 11 pounds, with flanged edges. The beams are fitted with tee braces 3½ by 3½ inches by 9.2 pounds for 200 feet amidships, the balance being 3 by 3 inches by 6.6-pound tees bracketed to shell plating and beams, and tied to beams with a 2½ by 2½-inch by 5-pound vertical angle carried for about 200 feet amidships. Between the steel guard beams are intermediate guard beams of 5 by 3½-inch yellow pine, with angle clips fitted on outboard ends connecting to wale piece.

There are three trussed wheel beams on each side, made up of 15-pound plates and 3 by 3-inch by 7-pound angles. The sponsons for the shaft pillow blocks consist of 20-pound knee plates, 25-pound top plates, 20-pound doubling plates, 20-pound and 8-pound bottom plates, 3 by 3-inch by 7-pound web angles, and 6 by 3½-inch by 16-pound top angles.

The engine and stack inclosures have coaming plates 12 inches high of 13-pound steel, the casing from main to shade deck being 8-pound plates, with 6-pound plates above the shade deck. This casing is stiffened inside with 3½ by 3-inch by 6-pound tee bars forming seam straps.

The rudder is of the balanced type, with frame, stock and arms forged in one piece of hammered iron, there being one cross arm and one diagonal arm. The stock measures 7½ inches in diameter at the head, reduced at the heel to 4½ inches. Side plates are of 11-pound steel. The rudder quadrant consists of a cast steel hub double bored and fitted to rudder stock by a key; it measures about 4 feet in radius to rim, which has the usual trough for steering chains.

The hull and side lights have composition frames, double hinges and single clamps. There are one hundred and twenty 10-inch lights and fourteen 8-inch. In addition there are ten escape ports measuring 10 by 18 inches in the clear, enabling the escape through them of any person who might be caught below in such an accident as that in the North German Lloyd steamers, in June of 1900.

The main deck plank is of clear Oregon pine in strips 2½ by 2½ inches. The plank sheer of white oak 14 by 3 inches; clamp, white oak, 12 by 3 inches; wales, white oak, 11 by 6 inches, with beveled joints. There is a facing wale of iron 10 by ¾ inches. The main rail is of yellow pine 6½ by 2½ inches; stanchions of oak spaced 42 inches apart, and measuring 3½ by 3 inches at bottom and 3 by 3 inches at top. Coamings on main deck are of yellow pine.

THE HULL OF THE HENDRICK HUDSON, MARCH 16, 1906, FIFTEEN DAYS BEFORE THE LAUNCHING.

THE MACHINERY.

The steamer will be propelled by a pair of paddle wheels actuated by a three cylinder compound engine, which is directly connected to the shaft without the intermediation of the customary rocking beam. These cylinders are arranged with the high pressure in the middle and have diameters respectively 70, 45 and 70 inches, the common stroke being 7 feet. The high-pressure cylinder has two balanced slide valves of a modified gridiron type, while each low-pressure cylinder has a single three-ported slide valve balanced by steam pressure on the back. The main steam inlet has a diameter of 14 inches.

The paddle wheels have a diameter over all of 24 feet, and are of the feathering type, with nine buckets each; the latter have a width of 4 feet and are 14 feet 6 inches long. The number of revolutions under full power (5,500 horsepower) will, it is anticipated, be 40 per minute. The shaft is of open hearth carbon steel measuring 18½ inches at the engine, and expanded to a diameter of 22 inches where it passes through the hubs of the wheels. Crank pins have a diameter of 18 inches, the throw being 42 inches. The flanges of the paddle wheel hubs are formed of solid steel castings, the arms being of wrought iron and offset. Connecting rods measure 16 feet 6 inches between centers.

donkey fire pump has cylinders 12 and 9¾ inches by 12 inches stroke.

There are four single ended and two double ended boilers, the latter being designed with independent combustion chambers; all are made to the same pattern, being 12 feet 4 inches in mean diameter and fitted with two furnaces in each of the single ended and two furnaces in each end of the double ended boilers. The furnaces are of the Morison suspension type, with an inside diameter of 44 inches. Anthracite will be burned in them. The boilers are respectively 11 and 22 feet in length, and are fitted with 2½-inch tubes. The aggregate grate surface is 424 square feet, while the heating surface, which bears a ratio to the grate of about 36 to 1, is 15,250 square feet. The steam pressure is 170 pounds per square inch. Forced draft is furnished under the Howden system, there being two Sirocco blowers with 51-inch wheels, operated by Fuller engines.

There are two 25-kilowatt generating sets from the works of the General Electric Company, operated by Curtis turbines direct connected, and furnishing direct current at a pressure of 110 volts. Steam steering gear will be fitted, with hand gear for relay.

THE FITTINGS AND DECORATIONS.

The interior finish of the dining room and of the grand saloons will be mahogany throughout, and the finish of the main deck forward of the dining room will be French gray oak, while the splendid obversation rooms will be finished in clear cypress, with dull green stain, all highly polished. A handsome dome of stained glass will top the upper grand stairway in the after cabin. There will be a number of special day parlors of large size arranged on either side of the saloon deck cabin, and two similar rooms on the shade deck, directly underneath the pilot-house. The two last named rooms will be decorated in Louis XVI style, finished in ivory enamel and gold. Those on the saloon deck will be decorated and furnished in the following distinct styles: Two Japanese rooms; four in the modern Art Nouveau style, in quartered oak, with unique decorations; two Dutch rooms, in oak, decorated in characteristic manner; two French Empire rooms, in mahogany and gold; and two rooms in the Colonial style, finished in poplar and mahogany. There will also be ten smaller rooms, handsomely decorated. A large and completely equipped teakwood writing room in the Persian style of decoration will be conveniently located for the passengers' use.

Among the mechanical fittings might be mentioned the Nicholson ship log; while the safety of passengers is secured by the usual equipment of life preservers and boats, and by eight Carley life floats, 6 by 10 feet in size.

The first trip is scheduled for August.

JUST AFTER LAUNCHING, MARCH 31, 1906. STEAMER NEW YORK IN FOREGROUND. HENRICK HUDSON IN MIDDLE DISTANCE.

The main bearings, four in number, are 16 inches long, with outboard bearings 18 inches in length. The boxes are of cast iron lined with babbitt metal. The crank pin boxes are of cast steel and are of the Scotch type, while the crosshead boxes are bronze, of the locomotive type with straps.

The crosshead pins, which have a diameter of 11 inches, are of open hearth carbon steel. The slides, acting as struts between the cylinders and the shafting, are also of open hearth carbon steel, and are six in number, two to each cylinder. The sliding faces are 12½ inches wide and the columns have a diameter of 8 inches. The crossheads and shoes are steel castings, the slippers being lined with babbitt metal and having a bearing surface measuring 12½ by 26 inches. All the engine castings are of steel, the bedplate being very light because of the excellent foundation built up from the frame work of the vessel itself.

A single surface condenser with 8,000 square feet of cooling surface has a diameter of 75 inches, and is fitted with ⅝-inch tubes measuring 14 feet 2¼ inches in length. The air pump is independent, of the Blake twin pattern, the air cylinder having a diameter of 28 inches. A centrifugal pump is fitted, furnished by the Morris Machine Works of Baldwinsville, N. Y. The main feed pump is also of the Blake pattern, being compound simplex with steam cylinders 14 and 20 inches and water cylinder 12 inches in diameter, and a common stroke of 18 inches. A

Published Monthly at
17 Battery Place - - - NEW YORK
H. L. ALDRICH, President and Treesurer
8 Finsbury Square - - London, E. C.
E. J. P. BENN, Director and Publisher

PROF. W. F. DURAND, Advisory Editor

SIDNEY GRAVES KOON, Editor

GEORGE SLATE
Vice-President and New York Representative

Branch Offices { Philadelphia, Pa., Machinery Dept., the Bourse, S. W. Anness.
Boston, Mass., 170 Summer St., S. I. Carpenter.
Chicago, 34 Clark Street, Howard S. Moss.
Midlands, 2 Sandhurst Road, Moseley, E. E. Starke.

TERMS OF SUBSCRIPTION

	Per Year	Per Copy
United States, Canada and Mexico	$2.00	20 cents
Great Britain and Ireland	10/6	1/
Other countries in the Postal Union	10/6	1/

Entered at New York Post Office as second-class matter.
Copyright, 1906, by Marine Engineering, Inc., New York.
International Marine Engineering is registered in the United States Patent Office.
Copyright in Great Britain; entered at Stationers' Hall, London.

Notice to Advertisers.

Changes to be made in copy, or in orders for advertisements, must be in our hands not later than the 8th of the month, to insure the carrying out of such instructions in the issue of the month following. If proof is to be submitted, copy must be in our hands not later than the 1st of the month.

The edition of the May issue of International Marine Engineering *comprises 6,500 copies. We have no free list, accept no return copies and issue only enough to supply the regular demand, so that the 6,500 copies represent legitimate circulation.*

Our Change in Name.

The rapidly increasing dimensions of our foreign business, together wth an appreciation of the extremely high position in the shipbulding line enjoyed by Great Britain, have led us to embark upon the publication of an English edition, which will be issued in London coincidently with the regular edition in New York. With the liveliest anticipations of an immensely increased patronage under the headings of both readers and advertisers in the British Isles, we have considered it best to become international in name as well as in fact, and hence have prefixed the word "International" to the previous name Marine Engineering, and will hereafter be known as International Marine Engineering.

There will be no change in our policy, which is, as it has ever been, to bring before our readers in a clear and concise manner everything of a marine or shipbuilding nature which might seem to be of interest to them, each and every item being taken up with as much attention to engineering details as possible. We expect to continue along these lines, improving month by month as much as may be, but following out in the main the schedule which has been found so successful heretofore.

In this connection, we will always welcome suggestions from readers, both as to policy and as to details, and trust that each of our friends will continue to feel at liberty to let us know whenever he has anything to suggest, either in the way of some construction which ought to be described, or in connection with any other item of interest.

The Powering of Battleships.

One of our articles this month describes at some length the trial trip of the battleship *Louisiana* and is noteworthy not only because of the large amount of information and data contained within itself, but also by reason of the side light which it throws upon results obtained from previous ships. What is necessary for an analysis of comparative results in this connection are figures for displacement, horsepower and speed on trial, with which might be included similar figures as estimated in the design. The *Louisiana* has a displacement of 16,000 tons, and was designed to obtain a speed of 18 knots with 16,500 horsepower. The result on trial was 18.823 knots with 20,443 horsepower.

The two ships with which we propose to compare this result are the *Virginia,* trial of which was described in our issue for March of this year, and the historic *Oregon,* which was tried more than ten years ago. The *Virginia* has a displacement of 14,948 tons, and was designed for a speed of 19 knots with the engines indicating 19,000 horsepower. The trial speed of 19.01 knots was obtained with 22,501 horsepower. The *Oregon* had a trial displacement of 10,242 tons, and was designed for a speed of 15 knots with 9,000 horsepower. The result obtained on trial was a speed of 16.79 knots with 11,037 horsepower.

The method of comparison in cases of this sort is to determine what is known as the Admiralty constant or Admiralty coefficient; this figure being based upon the two-thirds power of the displacement, multiplied by the cube of the speed, and divided by the horsepower at which the speed was attained. For the *Louisiana* this figures out at 220.4 under trial conditions, while the design called for 224.5. For the *Virginia* the design called for 219.5 and the result obtained was 185.5. With the *Oregon* the design called for 176.6 and the result obtained was 202. It might be mentioned in this connection that the hull of the *Oregon* was not subjected before her construction to model tests designed for the purpose of determining the best form for the results desired. That of the *Virginia* was so tested, but not to the same extent as was the case with the *Louisiana,* and as a result the latter ship has shown a much higher degree of performance, and a performance considerably superior to that of the *Oregon.* This is true not only in connection with the relation between hull, speed and power, but also in connection with the relation between the coefficient as designed and the coefficient actually obtained on trial.

In the *Louisiana* the coefficient on trial was somewhat less than that designed, which indicates that the performance was not quite so good as was anticipated. The difference, however, is so slight that the designed speed of 18 knots would have been attained under the same conditions as were observed in the trial of the ship, with 16,830 horsepower, as compared with 16,500 horsepower in the design. This increase of 2 percent indicates a very close agreement between design and result.

With the *Virginia,* the anticipated coefficient was very largely reduced when it came to practice, and as a result the designed speed of 19 knots was found to require 22,465 horsepower for its development, in place of the 19,000 called for by the design.

The *Oregon,* on the other hand, showed a marked superiority in performance over the design. The coefficient was increased from 176.6 to 202, and as a result the designed speed of 15 knots could have been attained with 7,860 horsepower as compared with 9,000 in the design.

When it comes to a comparison of the *Louisiana* with the other two, we find that the speed actually attained by the *Louisiana* would have required on the basis of the performance of the *Virginia* 24,230 horsepower. On the basis of the *Oregon's* performance, the requirement is 22,270 horsepower. There are thus savings respectively of 3,800 and 1,800 horsepower as compared with the two previous ships, an eloquent testimonial in favor of the value of systematically conducted model experiments as performed under the conditions available with the splendid equipment in the Navy Yard at Washington.

The results obtained by the *Oregon* were extremely good, not only for her type, but also for the date at which they were made. It is thus a case for congratulation that a later ship has been able to make a distinct saving on these results, as the *Louisiana* has done.

It is of course understood that this method of figuring comparative results is not always strictly applicable, because of the fact that, other things being equal, increase in size of ship conduces to an increase in the coefficient and an apparently better result under given conditions. On the other hand it may be stated that, other things being equal, an increase in the speed of the ship will produce a decrease in the coefficient and indicate an apparently less satisfactory result than with a lower speed. Minor conditions affect very markedly both of these considerations, as may readily be seen when the speed-power curve of a vessel is examined and the positions of its humps noted. On pages 286 and 289 of our issue for July, 1905, are shown curves of this sort in which the humps are very marked. It is needless to state that their positions and extent depend upon the length of the ship, and upon the form of the afterbody. Without such data to utilize it would, of course, be out of the question to attempt a thorough comparative analysis as between two or more ships, but the method adopted above is satisfactory in most cases, and will serve to show clearly the character of the results achieved during the last few years.

As indicating the increased efficiency of performance with decreased speed, figures might be taken from the speed-power curve of the *Louisiana* as completed, showing that at 16 knots the requirement was for 9,400 horsepower, giving a coefficient of 276.2; at 17 knots, with 12,350 horsepower, the coefficient is 252.6 and at 18 knots, with 15,850 horsepower, a coefficient of 233.3 is obtained. At the attained speed of the *Oregon,* 16.79 knots, the horsepower called for by the *Louisiana* is 11,650, with a coefficient of 253.8; this result is seen to be decidedly superior to that obtained with the *Oregon,* the power for a ship 50 percent larger in displacement having been increased by less than 6 percent, as compared with a theoretical 31 percent.

Fireproof Construction in Steamboats.

Late in March the Fall River Line steamer *Plymouth,* which was undergoing overhauling at Newport, was burned under circumstances which seem to call for an immense improvement in the construction of craft of this sort. It may be out of the question to render any such structure or vessel entirely fireproof, and even if this were not the case, it would probably be found inexpedient to incur the expense and other disadvantages which would be involved. In this case, however, the spread of the fire was so extremely rapid that a man was burned in his bunk (the fire occurred at night) and several other members of the force on board had considerable difficulty in effecting an escape. It would thus seem to have been simply a providential interposition in that the vessel was not heavily loaded with passengers, which prevented a repetition of a catastrophe similar in character, though possibly not in magnitude, to that which overtook the *General Slocum* two years ago. It is true that the *Plymouth* was a comparatively old vessel, she having been constructed in 1890, but this fact is no excuse for the existence upon her of conditions which gave rise to so extremely rapid a spread of fire. Every vessel of this sort, the upper works of which are in nearly all cases constructed almost entirely of wood, ought in all cases to be fitted with effective fire breaks in the shape of vertical transverse bulkheads of steel, extending continuously from the keel to the topmost deck, and provided with only a sufficient number of openings to permit easy access between the several portions of the vessel. This sort of construction would involve only a trifling increase of expense, and would afford immense additional security, not only to the passengers and crew on board, but to the vessel as a whole, because it would confine a sudden fire to a single compartment at least long enough to enable effective means to be employed in fighting it. It would in this case act in the form of a preventive insurance, and might easily in a short period more than pay for itself in the security afforded.

This construction is to be used to some extent on the new steamer *Hendrick Hudson* of the Albany Day Line, but in general the magnificent steamboats upon our sounds and rivers are entirely without fire protection of any sort.

ABSTRACT FROM RULES AND REGULATIONS OF BUREAU VERITAS.

EDITION OF 1905.

ARRANGED BY HARRISON S. TAFT.

PART I.

1. Measurements.

TABLE I.—MEASUREMENTS FOR SCANTLING NUMBERS.

Type of Vessel	Length L	Breadth B	Depth – D – for Regulating		
			Athwartship Number	Longitudinal Number	Equipment Number
1. All Single Deck Vessels with but one laid deck with or without a second tier of beams.	From after side of the stem to the fore side of the stern post (rudder post in screw vessels) on line of the upper deck in one and two deck vessels, but on line of the second deck in vessels with more than two decks.	Maximum Molded Beam	Molded to Upper Deck	Molded to Upper Deck	Molded to Upper Deck
2. All Two and Three Deck Steam Vessels having two or more tiers of beams, with at least two laid decks, one of which is of metal.			(a) Molded to Upper Deck	85% of Molded to Upper Deck	Molded to Upper Deck
(a) Trading round the world in all seas and of over 250 gross tons.			(b) Molded to Upper Deck	75% of Molded to Upper Deck	Molded to Upper Deck
(b) Engaged in general coast trade and of or above 70 tons.			Molded to Second Deck	Molded to Second Deck	Molded to Upper Deck
3. Spar Deck Vessels. (See section 33, paragraphs 2 and 6.)			Molded to Second Deck	As taken in Three Deck Vessels	Molded to Second Deck
4. Awning Deck Vessels.			Molded to Upper Deck	Molded to Upper Deck	Molded to Upper Deck
5. Raised Deck Vessels. (See section 35, paragraph 2.)			Molded to Upper Deck	Molded to Upper Deck	Molded to Upper Deck
6. Sailing Vessels. (Without a third tier of beams.)					

Depth to be measured from top of keel to top of above stated decks at side of ship amidships.
Scantling Numbers—Athwartship: $AN = B + D$. Longitudinal: $LN = L \times B \times D$. Equipment: $EN = L \times B \times D + \frac{1}{2}$ the capacity in cubic feet of the erections on deck.

1. SCANTLINGS UNDER ATHWARTSHIP NUMBER; Frames; reverse frames, floors, bulkheads.

2. SCANTLINGS UNDER LONGITUDINAL NUMBER; Stems; stern posts; bar keels; flat plate keels; shell plating; frame spacing; rudder head, heel and pintle; all keelsons; wood ceilings; members of double bottoms; hatch coamings, poop, forecastle, deck houses; casings.

3. Scantlings of Beams are regulated by midship length of the beams.

4. Scantling of decks, stringers and ties are regulated by length and depth only.

5. A reduction of ⅓ will be allowed on the equipment number as found by the above formula for the anchors and chain cables of full powered steamers. Stockless anchors are to be 25 percent heavier than otherwise, the weight of the shank being not more than ⅓ of the total weight of said anchors.

Note: The name upper or first deck refers in all cases to the uppermost or weather deck, whatever category the vessel may belong to: i. e., in spar deck vessels to the spar deck, in awning deck vessels to the awning deck.

2. Scarphs.

Scarphs of all bar keels, stems and stern posts should be in length not less than three times the required depth of the bar keel.

3. Stems.

Stems are to be of the same scantling as the bar keel. They should maintain their full sectional area up to the light load water line, with a gradual reduction above said line to their head, where the sectional area can be ⅔ that of the tabular area.

4. Stern Frames.

1. In sailing vessels, paddle and twin screw steamers, the stern frame should equal the scantling of the bar keel, with an increase over said scantling at the gudgeons if necessary. The sectional area of the stern frame can be gradually reduced above the counter so that it will be at least ⅔ of its greatest sectional area.

2. SINGLE SCREW VESSELS.

(*a*) PROPELLER POST.

That part of the propeller post above the boss can be gradually reduced, so that it will be of the same size as the rudder post at its junction with the same. The thickness on each side of the boss is to be at least ⅔ of the thickness of the lower part of the propeller post.

(*b*) RUDDER POST.

The sectional area of the rudder post is to be at least 90 percent of that of the propeller post. It can be gradually reduced in size from the lower part of the rudder trunk to its head, where its sectional area can not be less than ⅔ of the sectional area at the keel.

(*c*) That part of the stern frame between the two posts must have a sectional area equal to that of the propeller post.

3. The head of the stern frame should be securely fastened to the main deck beams by means of a transom plate. In all screw steamers the propeller post must be carried up and securely fastened to the second deck beams when the steamer's longitudinal number is 210,000 or above.

4. That part of the stern frame forming the after part of the vessel's keel should in all vessels extend forward of the propeller post, with a gradual taper to the size of the bar keel at its junction with the same, for a distance of at least 6 feet when the longitudinal number is under 140,000, but at least 8 feet when said number is over 140,000.

5. The gudgeons are to be spaced from 4 to 5½ feet apart, but never more than the latter. The thickness on each side of the pintle holes is to be at least ½ the diameter of said pintle, the depth of the gudgeons being at least 1¼ times said diameter.

6. The sectional area of the propeller brackets or struts of twin screw vessels should be about 40 percent of that of the shaft which they support.

5. Flat Plate Keels and Center Line Keelsons.

1. Flat Plate Keels with a Vertical Center Line Keelson.

(*a*) Said keel plates are to maintain their midship scantling for one-half length amidships. When they are over 25 pounds amidships their weight at ends must be not less than 5-6 of their midship weight. No reduction from midship weight will be allowed at the after end of screw steamers.

(*b*) When the longitudinal number is 450,000 and above, the flat plate keel is to be worked double for its entire length, the doubling plates being of the same thickness as the garboards.

(*c*) Said keels are to be fitted with a continuous or intercostal vertical keelson in all cases; a continuous keelson having a double angle bar (worked continuously) connection to said keel plates; an intercostal keelson being secured to said keel plates by double intercostal clips.

2. Center Line Through Plate Keel and Keelson.

Said keel and keelson must at least be equal in depth to the depth of the midship floor plates plus the required depth of the bar keel, and have side plates fitted below the floors. The depth of said side plates is to equal the depth of the tabulated bar keel, being of such a thickness that their combined thickness and that of the center keelson plate will not be less than that of the ordinary bar keel in lieu of which this form of connection is used.

3. Center Line Girder Keelsons on Top of Floors.

(*a*) Said girder keelsons are to consist of a vertical plate embraced by two top and bottom angles. A rider plate is to be worked on top of the two upper angles for ¾ length amidships.

(*b*) When the height of said keelsons is over 18 inches it shall be secured to a horizontal plate stringer riveted to top of floors on the center line, said stringer extending as far fore and aft as possible. If said horizontal plate is used when the height of the center keelson is under 18 inches a reduction can be made in the scantling of said girder keelson.

(*c*) Said girder keelson is to be of increased scantling wherever a mast is stepped on same.

4. Continuous Center Line Keelsons.

(*a*) All continuous keelsons under paragraphs 1 and 2 above are to extend as far forward and aft as practical, being worked continuously through all bulkheads, except the two peak bulkheads. They are to maintain their midship scantling for at least ⅔ length amidships with reduction of ⅓ in weight at ends beyond the fore and mizzen mast steps.

(*b*) When said keelsons under paragraphs 1 and 2 (above) extend above top of floors, a horizontal stringer plate, equal to weight of floors and in breadth not less than ¾ the depth of said floors, must be worked on top of floors on each side of the center keelson, being secured to said keelson by two continuous angle bars riveted back to back on top of said stringer plate and embracing the top of said center keelson plate.

(*c*) When said keelsons under paragraphs 1 and 2 (above) are worked flush with top of floors there is to be a center line horizontal plate stringer, equal to the weight of said center line keelson and in breadth at least 1½ times the depth of floors, on top of floors at center line; said horizontal plate being secured to the top edge of the center keelson by two continuous angle bars.

5. Intercostal Center Line Keelsons.

(*a*) When said keelson under paragraph 1 (above) extends above tops of floors it is to be worked as stated under paragraph 4-*b* (above), except that the thickness of the horizontal plate stringer is to equal that of the intercostal keelson.

(*b*) When said keelson under paragraph 1 (above) is finished flush with top of floors, it is to be worked as stated under paragraph 4-c (above) except that the thickness of the horizontal plate stringer is to equal that of the floors.

(c) Intercostal center line keelsons are to have a double clip connection to floors.

6. Frames.

1. Frames are to maintain their midship scantling for ½ length amidships, with a reduction at ends. No reduction will be allowed forward of said ½ length when the transverse number is 71 and over.

2. All frames are to extend in one length from the center line to the upper deck stringer in all vessels except awning deck vessels, and in way of poops, bridgehouses, and forecastles, where the frames are to extend to the stringers of said decks or to the lower part of a rounded gunwale if used.

3. Scarph pieces of the same scantling as the frames, and of sufficient length to allow of three rivets in each flange on each side of the butts, are to be worked across the line of keel for ¾ of the vessel's length amidships. They are to be roved through a "Center Line through plate keel and keelson," but need not be used when a flat plate keel is adopted.

4. In vessels with a speed of 14 knots and over, the frames abaft the stuffing box bulkhead of the stern tube should be worked double at least up to the lower deck; or an intercostal plate stringer chocked to shell may be substituted.

5. In vessels with their machinery located aft, the frames in the machinery space and coal bunkers are to be of midship scantling.

6. At watertight decks or flats it is recommended that the frames with their reverse frames be cut, with knee brackets fitted on both sides of the stringer plates to connect the interrupted frames thereto.

7. Frames at all watertight bulkheads are to be worked double. Single frames may be used if both flanges are wide enough for double riveting.

8. For vessels navigating in ice the frames from the stem to 2 frames abaft the forward collision bulkhead must not exceed ⅔ of their midship spacing.

9. The vertical flange of the frame bar on solid floors within a double bottom may be of the same width as the shell flange.

7. Floor Plates.

1. A floor plate is to be fitted to every frame, being secured to a continuous or intercostal center line keelson by double clips equal to the reverse frames. They are to maintain their midship weight for ½ length amidships, being reduced at the ends. In full form vessels the floors at the forward end should not be reduced more than 1-32 inch for about 15 percent of the vessel's length abaft the collision bulkhead, whether the vessel has a double bottom or not.

2. Floors are to extend up the bilges above the base line to at least twice their center depth amidships for the greatest possible length. At the lower turn of the bilge they should not be less than ½ their center line depth. Towards the ends of the vessel they may gradually be reduced in height at the bilges until they become straight on their upper edge. At the very extreme ends their depths should be increased. In the aft peak of screw steamers they should be of extra depth so as to securely stiffen the after body.

3. All floors in the machinery space and coal bunkers are to be of increased weight.

4. Bulkhead floors are to be deep enough so as to allow the bulkhead plating to be riveted to them above the ceiling and also to fit the keelson collars clear of said landing.

5. Suitable limber holes are to be cut in all non-watertight floors, longitudinals, and wash plates so as to provide for a free flow of water to the pumps.

6. Transom Floors.

On middle line they are to be at least 1½ times the depth of midship floors, but of the same weight. They are to be securely fastened to the head of the stern frame.

8. Reverse Frames.

1. A reverse frame is to be fitted to the top of every floor. They are to maintain their midship scantling for ½ length amidships. They should be fitted in one length, with their butts at the center line well scarphed with an angle clip of the same sectional area as the reverse frames, having at least three rivets in each flange on each side of the butt.

TABLE 2.—EXTENT OF REVERSE FRAMES.

Type of Vessel	Depth	Under 12½ ft.	12½ ft., under 14½ ft.	14½ ft. and above
In General	Extent of Reverse Frames	To Upper Deck and to Upper Turn of bilge alternately	To Upper Deck and to above the Side Stringer Angle Bar alternately	To Upper Deck and to above the Second Deck Stringer Angle Bar alternately
Awning Deck Vessels	Longitudinal Number	Under 270,000	270,000, under 450,000	450,000 and above
	Extent of Reverse Frames	A to top of the Second Deck Stringer Angle Bar	To Awning Deck Strioger on every fourth frame. Others to Second Deck as before	To Awning Deck Stringer and to top of the Second Deck Strioger Angle Bar alternately
Spar Deck Vessels	Extent of Reverse Frames	1. To Upper Deck and to above the Second Deck Stringer alternately. 2. In vessels whose longitudinal number is under 187,500 and having only light deck houses, all reverse frames are to extend up to the spar deck throughout the length over which said deck houses extend, unless partial bulkheads are fitted between decks.		
Sailing Vessels		All to Upper Deck in vessels of 21 or more feet depth to said deck.		
Side Wheel Steamers		All to Upper Deck Stringer in way of paddle boxes; or other stiffening in lieu of said reverse frames.		

2. No reverse frames will in general be required in poops or bridge houses unless there are erections upon said decks. They can also be omitted in top gallant forecastles unless there is danger of said forecastle being damaged by the seas.

3. In coal bunkers and in machinery spaces the reverse frames are to be worked double on every floor, those in the way of coal bunkers being the same thickness as the frames. Said doubling is to extend to the lower turn of the bilge in steamers of less than 16-foot depth, but to the upper turn of the bilge in all other steamers, except in double bottom vessels, where said doubling need not extend beyond the margin plates.

4. Compensation must be made where reverse frames are cut at a watertight flat.

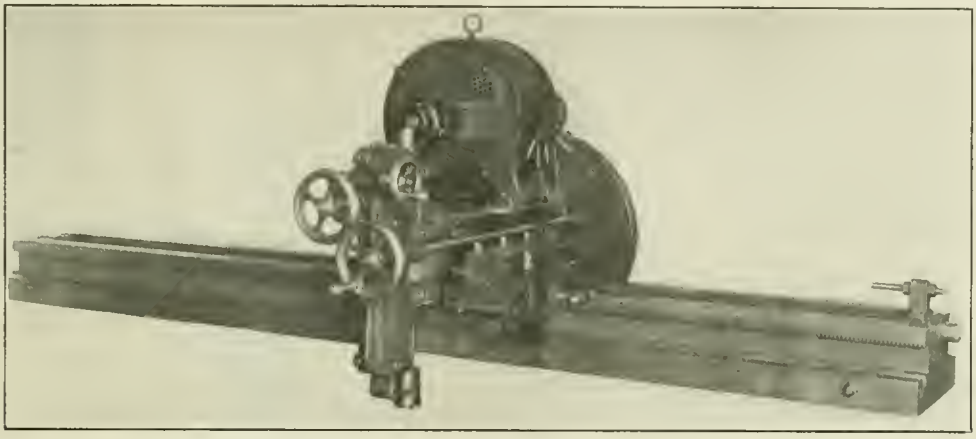
5. (*a*) When a center line keelson extends above top of floors as stated under section 5, paragraph 4 the reverse frames which are cut at said keelson must be scarphed by an angle lug roved through said keelson, the lug being in length equal to the combined width of the two horizontal plates on top of floors.

(*b*) When the center line keelson is worked flush with the top of floors the above scarph pieces can be omitted, but reverse angle lugs, equal in length to at least ½ the breadth of the stringer plate on top of floors at center line must be worked in their place on top of floors on each side of the center keelson.

ENGINEERING SPECIALTIES.

Underwood Portable Milling Machine.

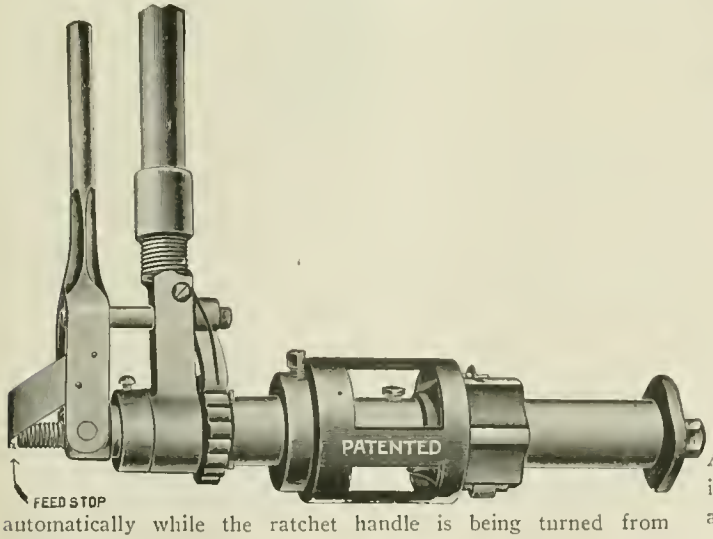
One of the special tools recently placed upon the market by H. B. Underwood & Company, 1025 Hamilton street, Philadelphia, Pa., is a portable milling machine, which is an outgrowth from a temporary rig which they had to devise to do a certain job in place on a large machine. This miller is designed for straight line work of a maximum length of 8 feet, with a number of surfaces in line but on different planes. As shown in the illustration, it is driven by an electric motor, and can be so utilized as to work on a machine after all the parts are assembled. The carriage has a travel of 8 feet, with automatic feed, and the cross slide has a range of 12 inches, the vertical spindle being movable through a distance of 10 inches. The bed is mounted on a sub-base, allowing accurate adjustment by set screws before starting work, while the sub-base is secured to the work by means of clamps or bolts bearing in slots in the usual manner.



Ideal Self-Feed Tube Cutter.

The accompanying illustration shows the Ideal self-feed tube cutter, built by Gustav Wiedeke & Company, Dayton, Ohio. With this cutter tubes can be cut off either inside or outside of the boiler head, and the manufacturers claim that it has solved the problem of cutting off steel tubes without cracking them. The tool is simple in construction and needs very little explanation.

When cutting off tubes, the feed handle is put on the stud parallel with the ratchet handle; the feed handle feeds itself automatically while the ratchet handle is being turned from left to right, in cutting off the tubes. All tubes are usually cut off before the feed rod touches the angle-iron on the feed handle. This tool cuts off all the tubes the same distance from the head, and can be set for any distance, no matter if the tubes project from ½ to 4 inches from the boiler head. It cuts them off with a bevel ready for beading, and rolls the tube at the same time, which is a great advantage. All the change necessary to be made from cutting off tubes from the outside to cutting off on the inside of the head is to move the cap back. This can be done in half a minute.

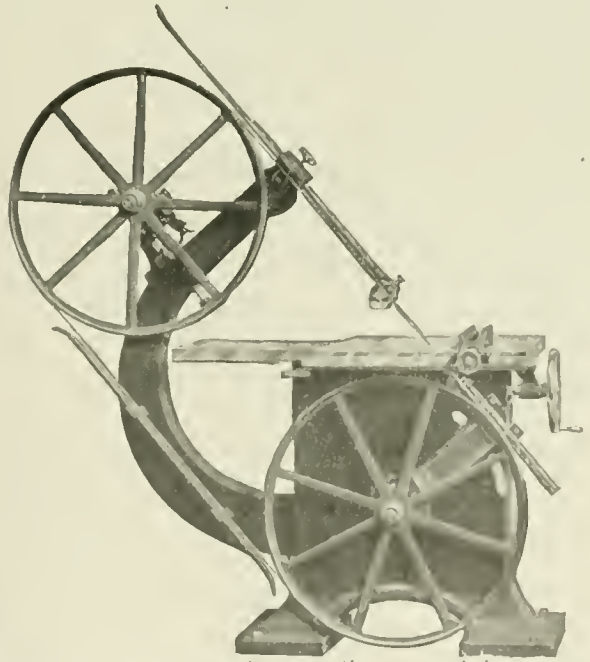


The body of the tube cutter, and all the small parts are made of steel, which limits wearing and prevents breaking. Turning is by means of a ratchet, very simply made. The feed handle is swivelled in order to get close to the boiler shell.

The Crescent Angle Band Saw.

The advantage of a band saw on which the table is always level, but which admits of tilting the saw for bevel work, is at once apparent; since it is so much easier to handle the work on a level table than on an inclined one. On large work it means the saving of an extra man helping to hold the work, while the smaller work can be turned out more accurately and in less time.

A new machine that is said to be thoroughly practical has been developed by the Crescent Machine Company, Leetonia, Ohio.



All the parts are automatic—no adjustments being necessary in changing the angle of the saw. The entire operation is accomplished by simply turning the handwheel at side of table until pointer indicates the desired angle on the graduated quadrant on the pedestal; and this may readily be done while saw is in motion. The location of the drive-pulley is not

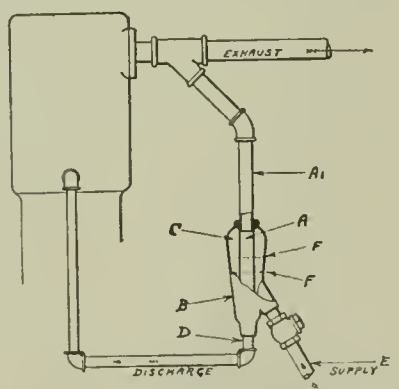
changed. The table is carried back on the pedestal in exact unison with the saw, so the saw keeps its proper position in the saw-slot. Both the lower and the upper guide are kept in alignment with the saw. The tension of the saw does not change.

The arm is hinged to the pedestal in a very rigid manner by means of a heavy trunnion passing through them, concentric with lower shaft, making the machine just as rigid when tilted as when standing erect. The bearings for lower shaft consist of solid bushings fastened into trunnion, and are provided with oil-chamber and capillary felt, making them practically self-oiling and dust-proof. The upper bearing is made with revolving shaft running in adjustable bearings. The table slides on the planed ways of the pedestal, and is provided with a steel gib for taking up possible wear. The saw will tilt back to an angle of 45 degrees, a stop being provided at that point; it may be also tilted forward to 4 degrees beyond the perpendicular. A stop is provided on the perpendicular point, but this stop can be swung out of place at will.

An Exhaust Operated Pump.

Exhibited by Curtiss & Waterhouse of New York at the recent Motor Boat Show, the pump is said to be a new application of hydrostatic principles which are very old and simple, and to be reliable and cheap to operate. It can be used on steam, gas or gasoline engines, for lifting water to floors above the engine, for pumping water into tanks, for pumping oils or acids and particularly for circulating water through engine jackets and for bilge purposes.

The diagram shows it connected to a small marine gasoline engine. At the first explosion, part of the exhaust gases enters the

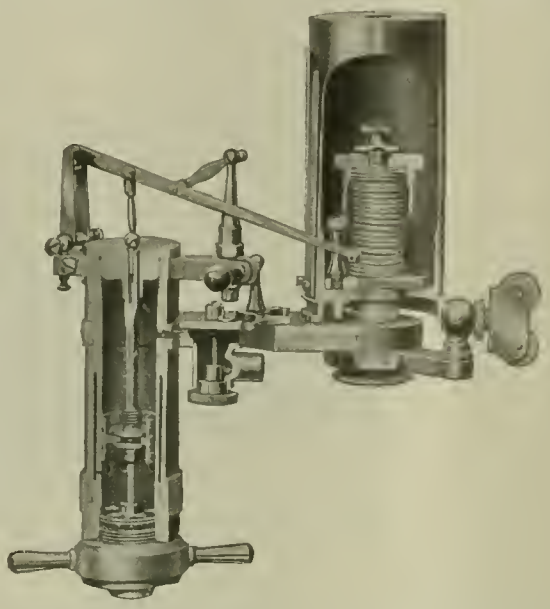


pump through *A* and into *C*. This creates a vacuum which operates to draw water through a check valve and supply pipe, *E*, and fills in and around *A*. After this the successive impacts from the explosions act upon the air in *A*, causing it to drive part of the water out through outlet *D*, which creates a vacuum in chamber *C* and again renews the supply of water through *E*, thus maintaining the water in pump at or about the level shown at *F*.

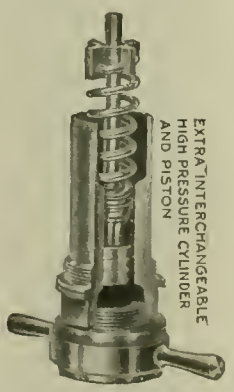
The pump is a single casting, and the simplicity of the pipe attachment and check valve stands out in strong contrast to the usual gearings, sprockets, chains, eccentrics, straps, plungers, packing and oil cups that require so much attention. For multiple-cylinder engines, where the water is discharged into the exhaust pipe, and for slow-running stationary engines that are lifting water to a considerable height, a check valve is used in the discharge pipe in addition to the one in the supply pipe. But for circulating water through the jackets of automobile engines or other engines of that class, no valves whatever are used, and there is absolutely nothing to wear out, nor is there any limit to the speed at which the engine may be run.

Lippincott High-Pressure Indicator.

Improvements in the indicator manufactured by the Lippincott Steam Speciality & Supply Company, of Newark, N. J., have recently been made. In general design the new instrument is similar to the older pattern, having a frictionless piston which consists of a piston head mounted on the piston rod between two ground steel flanges, and so designed that it has



a very small lateral movement. The rod is guided by an accurate bearing at the top and bottom, and the piston is therefore free to adapt itself to a central position in the cylinder, thereby practically eliminating friction. The exhaust steam is carried away through a swivel elbow which may be turned in any direction, a point which will be appreciated by engineers who are compelled to use the instrument in contracted quarters.



The indicator is fitted with a piston of one-half inch area; but it is accompanied by another interchangeable cylinder of one-quarter inch area for high pressure work. The outfit includes a very compact reducing wheel attached directly to the indicator. This wheel has bushings to adapt it for all ranges of stroke, and a very simple "spring winding mechanism" for adapting the spring in the wheel to different speeds.

Decision has been handed down by Justice Buffington of the United States Circuit Court sustaining the validity of the Robert Munroe patents for man hole covers for boilers. The decision is a very broad one and it is understood will have a good deal of effect in the marine field. The claim is made that the Munroe method is the only up-to-date one for making man holes, which is allowed in marine service where high pressures are used.

TECHNICAL PUBLICATIONS.

Valve Gears For Steam Engines. By Cecil H. Peabody, Professor of Naval Architecture and Marine Engineering, Massachusetts Institute of Technology. Size, 5¾ by 9 inches. Pages, 142; folding plates, 34. 1906, New York. John Wiley & Sons. Price, bound in cloth, $2.50.

This is the second edition of a work intended to be used as a text book for students in engineering colleges. The aim of the work is to give the student a firm grasp of the principles involved in the more usual types of valve gears, and some facility in their application, rather than present an exhaustive treatise covering the vast number of valves and gears now in use. The changes made from the earlier edition are mainly in the way of simplification in methods for solving problems; and include a transfer of the analytical work to an appendix, in which are discussed crank and connecting rod, eccentric and eccentric rod, Stephenson link motion, general equative treatment covering the vast number of valves and gears the Walschaert gear. The mathematics involved includes plain trigonometry, but nothing higher.

Graphic methods are used throughout the book, both for demonstration of principles and for designs of gears. In a few cases, where this form of construction would not be satisfactorily complete, reference has to be made to the appendix. Considerable attention is given to the Corliss gear, particularly with reference to drop cut-off gears.

Eminent Engineers: Brief Biographies of Thirty-two of the Inventors and Engineers Who Did Most to Further Mechanical Progress. By Dwight Goddard, A. S. M. E. Size 5½ by 7¾ inches. Pages, 280; illustrations, 35. New York, 1906. The Derry-Collard Company. Price $1.50.

This little book is a series of short biographies of American and European engineers and inventors, the amount of space devoted to each one ranging from four to twelve pages. The sketches include merely the salient features of the various lives, together with a description of the work for which each is best remembered. Each sketch is illustrated by a portrait of the engineer in question, there being in addition three or four other illustrations covering some of the most important of the work. It will suffice to list the names included in the short biographies, there being sixteen American and sixteen European included. The Americans are: Benjamin Franklin, John Fitch, Nathan Read, Oliver Evans, Robert Fulton, John Stevens, Robert L. Stevens, Eli Whitney, Thomas Blanchard, Elias Howe, John Ericsson, Peter Cooper, George H. Corliss, Alexander L. Holley, William R. Jones, and James B. Eads. The British are: Richard Arkwright, Thomas Newcomen, James Watt, Matthew Boulton, William Murdock, William Symington, Richard Trevithick, Henry Maudsley, George Stephenson, I. K. Brunel, James Nasmyth, Charles Babbage, Sir Joseph Whitworth, Sir Henry Bessemer; German, Alfried Krupp, Sir William Siemens.

Injectors: Their Theory, Construction and Working. By W. W. F. Pullen, M. I. M. E. Size 5 by 7. Pages, 208. Figures, 148. 1906, New York: D. Van Nostrand Company, and Manchester: the Technical Publishing Company, Limited. Price $1.50 net.

This is the third edition of the work, the other two having been issued in 1893 and 1900 respectively. The theory of the injector is taken up in considerable detail, and a large number of forms described and illustrated, both by photographic reproduction and by sketches. Curves are given showing the workings of injectors under various conditions of head and of delivery diameters, and instances are cited where injectors are used for a great variety of purposes. Among these might be mentioned the spraying of oil into a furnace using both oil and coal as fuel; the spraying of steam into a furnace in connection with oil for this same purpose; the use of an injector in connection with the sand box for sanding the rail of a railroad. The historical portion of the work has been placed in the rear and all together, in order that the general reader might follow out the stages of development without having to pick out the individual items from among the mass of theoretical considerations in the rest of the book. Regret is expressed in the preface that the difficulty of securing American examples for illustration and description has cut down the number of devices of American origin in the work to a very considerable degree, nearly everything included being British.

Steam Turbines: Their Development, Styles of Build, Construction and Use. By Wilhelm Gentsch. Translated from the German by Arthur Liddell. Size, 7 by 10¼ inches. Pages, 376. Illustrations, 637, including 19 plates. 1906, New York. Longmans, Green & Company. Price $6.00 net.

The rapidly increasing literature on this very live topic has received a noteworthy addition in the present contribution, which goes into the subject with characteristic German thoroughness in the matter of description and illustration, but which avoids completely all reference to the general theoretical aspects of the situation. This being the case, mathematical treatment is entirely omitted, the work being confined to descriptive material in great profusion, and covering large numbers of different types of apparatus.

The portion of most interest to our readers is the last chapter, which covers seventeen pages, and is devoted to steam turbines for use on shipboard. In this chapter descriptions are given of Parsons outfits, together with some information regarding those of the Rateau and the Schultz turbines, with a list of vessels propelled by Parsons turbines, and with plates showing the arrangements of these turbines in passenger steamers, torpedo boats and small cruisers. Quite a little information is given regarding the vessels in question with regard to dimensions, trials, economy, etc.; and a large amount of data is included in the work as a whole, covering tests of turbines under widely varying conditions, and operating for various purposes.

The use of superheated steam receives rather scanty attention in the chapter devoted to it, but is taken up to some extent in other places in discussion of tests in which superheated steam is used. The utilization of the exhaust steam is given some attention. The subjects of bearings and stuffing boxes are given well deserved attention, these items being, of course, very closely related to the efficient operation of the turbine. Governing appliances are given a chapter in which centrifugal and electrical governors are considered. Some attention is paid to reversing gear and descriptions are given of certain attempts to reverse the direction of operation of a turbine designed to revolve in one direction. As is well known, these attempts have up to date been practically failures, it being found necessary in cases where reversing is desired to resort to the addition on the shaft of a separate turbine for that purpose.

United States Civil Service Commission announces the following examinations:

May 2, electrical assistant in signal service at $900 per annum.

May 2, 3 and 4, structural and mechanical engineer draftsman in the engineering department at large at $1,320 per annum.

May 3 and 4, assistant electrical engineer, signal service in department of California, at $1,400 per annum.

May 9, nautical expert in Hydrographic office, Washington, at $1,000, and Cleveland, at $1,200 per annum.

Applicants in each case should apply to Commission in Washington for form 1312.

The examinations will be held at the usual places throughout the United States.

QUERIES AND ANSWERS.

All reasonable questions concerning marine engineering received from and signed by subscribers will be answered by the Editor in this column. All communications must bear the name and address of the writer.

Q. 330.—I wish to ask for an explanation, in your columns, as to the leading methods of constructing patterns and sweeping molds for propellers; also when one method is used and when another. T. McC. G.

A.—The article beginning on page 184 of this number answers fully the above query.

Q. 334.—Would you kindly answer the following at your first opportunity?

Which is considered the better practice for bracing the top of combustion chamber of a Scotch boiler: the girder brace or the crowfoot braces to shell? E. J.

A.—General practice prefers the girder brace to the crowfoot brace and this form of bracing will be found in nearly all examples of recent high grade practice, especially where high pressures are utilized. In a few cases the girders are reinforced by stays running to the boiler shell.

Q. 337.—As a subscriber through the Coast and Geodetic Survey and a possessor of a copy of *Practical Marine Engineering*, I respectfully request information regarding construction of fire tube boilers, pages 87-88, which states as follows:

"So far as internal pressure is concerned the boiler is twice as strong to resist rupture around girth as lengthwise, etc."

I do not quite fully understand the causes, and I am afraid I could not give as intelligent an answer as I would like to at the examination for Inspector of Boilers, which I intend taking shortly.

(2) Also kindly inform me if you have a very late edition of *Practical Marine Engineering;* the one I possess is of the second edition. M. F. F.

A.—The reason a boiler is twice as strong to resist rupture around the girth as it is lengthwise bears entirely upon the relation between the amount of force applied to disrupt the boiler and the amount of material tending to prevent its being disrupted.

The stress that tends to disrupt a boiler around the girth is made up of the total boiler pressure applied to one end of the boiler, and is, therefore, equal to the pressure in pounds per square inch multiplied by the cross sectional area of the boiler. Expressed algebraically, this will be equal to $p \times \frac{\pi d^2}{4}$. The resistance is that supplied by a circular ring of the boiler material of which the thickness is t and the diameter d. The area of material in this ring is obviously $t \times \pi d$. The amount of stress per square inch of material is found by dividing the first quantity by the second, and the result is $\frac{p d}{4 t}$.

When it comes to a question of rupturing the boiler lengthwise, we find that the steam is pressing against the inside surface of the shell equally in all directions, but it may be shown that the force tending to tear out the boiler along longitudinal seams is equal to the pressure multiplied by the length of the boiler times its diameter. In other words, the total amount of force applied by the internal pressure on the inside of the boiler may be represented by the amount which would be applied upon a longitudinal plane passing through the center of the boiler. It will be seen that in this case the force tending to rupture the boiler is equal to $p \times d \times l$. The resistance is offered by material distributed along the two sides of the boiler, and represented by $2 t \times l$. The stress per square inch of material will be, as before, the former quantity divided by the latter, the value being $\frac{p d}{2 t}$.

If we assume a boiler pressure of 150 pounds gauge per square inch, a mean diameter of 10 feet (120 inches), and a boiler shell thickness of 1 inch, it is readily seen that the stress tending to rupture the boiler around the girth is in this case 4,500 pounds per square inch, while that tending to rupture it longitudinally is 9,000 pounds per square inch.

(2) The second edition of Durand's *Practical Marine Engineering* is the one now current.

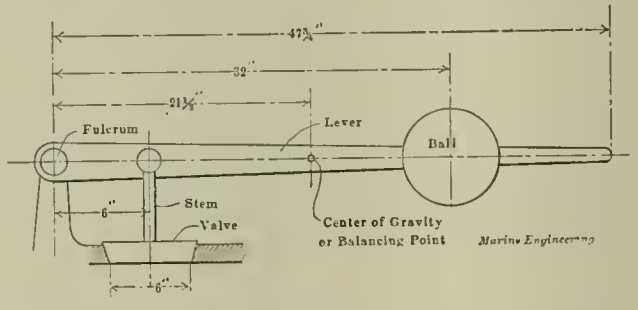
Q. 339.—Will you kindly, in your columns, give me the formula for calculating the period of torsional vibration of a propeller shaft? F. H. B.

A.—The question of the period of torsional vibration of a propeller shaft is a somewhat complicated one, but in general it may be stated that the period may be represented by the following equation: $t = 2 \pi R \sqrt{\frac{ML}{GI}}$ where t is the period in seconds, R is the radius of the crank in inches, M is the mass of the crank reduced to the crank circle, L is the maximum momentary difference between the work of the turning force and the resistance of the propeller, G is the weight of the reciprocating parts of the engine and I is the polar moment of inertia of the entire rotating mass about the center of the shaft.

The formula is from Bauer: *Marine Engines and Boilers.*

Q. 340.—Will you please give in your Queries the United States rules for working out safety valve problems, solved by plain figures. Say we have a safety valve of the following dimensions:—diameter, 6 inches; weight of ball, 160 pounds; length of fulcrum, 6 inches; length of lever, 47¾ inches; balancing point, 21½ inches. The ball is 32 inches from fulcrum; weight of lever, 18 pounds; weight of valve and stem, 15 pounds; steam pressure, 33 pounds. W. M. F.

A.—Our correspondent gives the entire amount of data, leaving no unknown to be determined. Analyzing this data, the diagram shows the general arrangement of the different parts, all of which act about the fulcrum. The pressure of the steam is the only upwardly acting force with which we have to deal. This is represented by a force of 33 pounds per



square inch on a circle of a diameter of 6 inches. The resultant total pressure is readily found to be 933 pounds. This is acting at a distance of 6 inches from the fulcrum and, therefore, constitutes an upward moment of 5,598 inch-pounds, which is to be offset by the combined downward moments of the various parts of the apparatus. The latter moments are three in number, those due to the ball, the lever, and the valve and stem, respectively. In this case the ball, which weighs 160 pounds and is distant 32 inches from the fulcrum, gives a moment of 5,120 inch-pounds; the lever, which weighs 18 pounds and the center of gravity of which is 21½ inches from the fulcrum, gives a moment of 387 inch-pounds. The valve and stem considered collectively weigh 15 pounds, and are at a distance of 6 inches from the fulcrum, thus giving an upward moment of 90 inch-pounds. The aggregate of these three is 5,597 inch-pounds, whence we see that the pressure of 33 pounds per square inch is just about sufficient to cause the valve to lift. In other words, the valve is about to blow off.

Q. 341.—Will you please give United States Rules

(1) To find the pressure at which a safety valve is about to blow off.

(2) To find the distance from the fulcrum to the point at which the weight must act in order to have the valve blow off at a given pressure.

(3) To find the weight which must act on a lever at a given distance from the fulcrum so that the valve will blow off at a given pressure.

(4) To find the downward force on valve due to weight of lever, valve and stem. F. M. W.

A.—The first three of these items depend upon the fundamental equation of the safety valve, which is:

$$Pv = Bb + Ll + (V - S)v,$$

where P is the total pressure of the steam on the valve, B is the weight of the ball, L that of the lever, and V and S

the weights of valve and stem respectively (these two latter are always considered together). The distances from the fulcrum to the valve, the ball and the center of gravity of the lever are respectively v, b and l. If we denote by p the pressure of the steam in pounds per square inch, and by d the diameter of the valve in inches, we find that $P=\frac{\pi d^2 p}{4}$ ($\pi=3.1416$).

(1) To find the pressure at which the valve is about to blow off, we substitute for P in the fundamental equation its value as just given above, and then solve the resultant equation for p. This gives us a result as follows:

$$p=\frac{4}{vd^2\pi}\times\left\{Bb+Ll+(V+S)v\right\}.$$

(2) Solving the same equation for b, which is the distance of the weight from the fulcrum, we obtain:

$$b=\frac{vpd^2\pi}{4B}-\frac{Ll}{B}-\frac{(V+S)v}{B}.$$

(3) For the weight of ball to be placed at a given distance from the fulcrum:

$$B=\frac{\pi d^2 pv}{4b}-\frac{Ll}{b}-\frac{(V+S)v}{b}.$$

(4) The downward force on the valve due to the weight of lever, valve and stem is found by dividing the sum of the moments of these items about the fulcrum, by the distance of the valve from the fulcrum. As the valve and stem are already at this same distance, all we have to do is to add to their weight, the quotient obtained by dividing the moment of the lever by the distance of the valve from the fulcrum. Using the same notation as above, and calling F the downward force of lever, valve and stem as applied on the valve, we find that

$$F=\frac{Ll}{v}+V+S.$$

The Bureau of Navigation of the Department of Commerce and Labor reports the construction during March of 87 vessels of a total of 73,519 gross tons. Of this total 15, covering 70,262 tons, are steel vessels propelled by steam. In this list are included 7 of more than 6,000 tons on the Great Lakes, aggregating 47,309 tons, and 1 for the New York and Cuba Mail Steamship Company, of 6,207 tons.

The returns for the quarter ending March 31 show a total of 202 vessels aggregating 106,834 tons, as compared with 159 vessels of 62,744 tons in the corresponding quarter of last year. The increase was entirely on the Great Lakes, there being a net decrease of over 20,000 tons on the Atlantic. Of the present total 19, amounting to 83,837 tons, were on the Great Lakes, and 183 of 22,997 tons, or an average of 126 tons each, elsewhere.

Returns are given for nine months ending March 31, showing the construction of 744 vessels aggregating 242,931 gross tons, of which 76 vessels amounting to 165,741 tons were on the Great Lakes and 668 of 77,190 tons elsewhere. The latter averaged 116 tons, while those on the Great Lakes averaged 2,180 tons. In the nine months, the construction on the Lakes was 142,453 tons greater than last year; that on the Atlantic coast was 52,456 tons less than last year.

Personals.

R. R. Row, formerly superintendent of construction in the U. S. Lighthouse Service has become general superintendent of the marine and mechanical department of the James Reilly Repair & Supply Company, New York, N. Y.

S. H. Pitkin has been appointed first vice-president and general manager of the Wellman-Seaver-Morgan Company of Cleveland, O., to succeed Charles H. Wellman, who was killed last June.

Captain Worth G. Ross of the United States Revenue Cutter Service has been appointed permanent Chief of Division of the Service dating from April 1. Captain Ross succeeds himself, the previous appointment having been for one year.

A new co-partnership of consulting engineers, consisting of John C. Kafer, late superintendent of Quintard Iron Works, Asa M. Mattice, late chief engineer Allis-Chalmers Company and Benjamin H. Warren, late president Allis-Chalmers Company, has been formed under the title Kafer, Mattice & Warren, with offices at 60 Wall street, New York. The scope of the work of the new firm is very considerable. It includes among other things examination and valuation of steamships and yachts, and specifications and plans for marine machinery.

No sooner had this announcement been received than it was learned that on March 30 Mr. Kafer had died at Trenton, N. J., where he was born in 1842. He served in the United States Navy during the latter half of the Civil War, and subsequently until 1885, when he became associated with the Morgan Iron Works, and later with the Quintard Iron Works.

Obituary.

George C. Cook, of the firm of Adam Cook's Sons, manufacturers of lubricants, died suddenly March 21.

New Shipping Lines.

It is reported that a shipping company organized at Cardiff is to establish a line of steamers between Great Britain and the colonies, and it is proposed to construct six ships of 15,000 tons each, driven by steam turbines.

Another report, emanating from Buenos Ayres, states that a company of Argentine capitalists has been organized to establish a line of steamships between Buenos Ayres and the Pacific, the points of call being Puerto Gallegos, Punta Arenas, Valdivia, Coronel, Conception, Valparaiso, Iquique and Callao. The capital of the company is two million dollars in gold, and one large steamer has already been acquired.

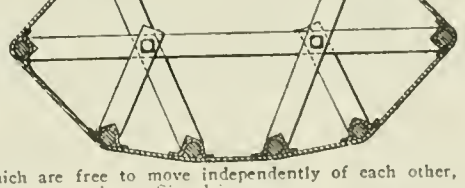
When are the Americans going to start?

SELECTED MARINE PATENTS.

The publication in this column of a patent specification does not necessarily imply editorial commendation.

808,302. COLLAPSIBLE OR FOLDING BOAT. CHARLES H. PAINE, ENGLEWOOD, N. J.

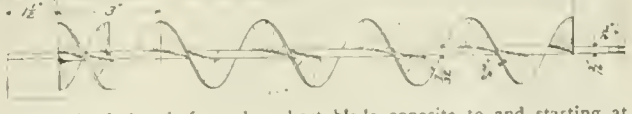
Claim.—1. A boat having a flexible covering, a plurality of resilient longitudinal ribs extending substantially from end to end of the boat, the



ends of which are free to move independently of each other, and one or more transverse spreaders. Six claims.

808,814. PROPELLER-WHEEL. FRANK CHIMZAR, ELY, MINNESOTA.

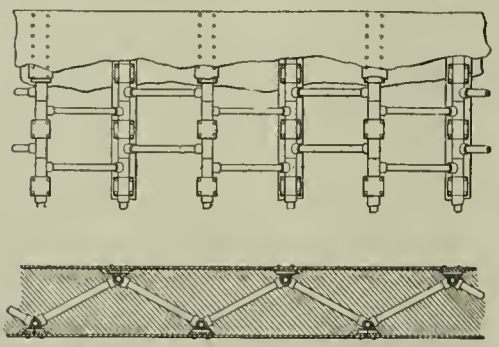
Claim.—The screw-propeller comprising a shaft, the long blade forming a continuous spiral blade of low pitch, having its convolutions extending from



end to end of the shaft, and a short blade opposite to and starting at a point abreast of the front end of the first convolution of the long blade, making one-half a convolution around the shaft and terminating with the first half-convolution of the long blade. One claim.

808,467. METHOD OF CONSTRUCTING VESSELS. EDMOND MOLLOY, PHILADELPHIA, PA.

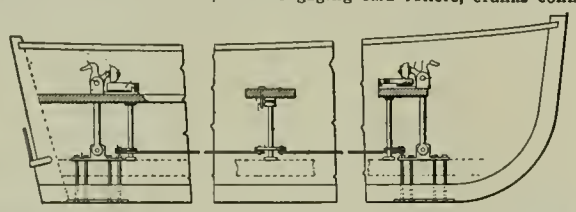
Abstract. The object of the invention is to produce a skeleton framework of novel construction, which is combined with appropriate sections of sheathing and with a suitable backing or filling material in such a way as to produce a simple, strong, and durable structure. The skeleton frame-



work comprises a plurality of runners and sectional stems intermediate of said runners, each stem consisting, preferably, of couplings and adapted for adjustment so as to exert tension on the runners, and thereby produce a rigid skeleton structure. Said skeleton structure and the sheathing are adapted for attachment one to the other, and the spaces between the sheathing and the structure are occupied by the filling or backing material, so as to secure a solid, rigid, and fireproof structure. Seven claims.

808,575. MEANS FOR RELEASING BOATS FROM THEIR FALLS AT BOTH ENDS SIMULTANEOUSLY. G. S. A. RANKING, CALCUTTA, INDIA.

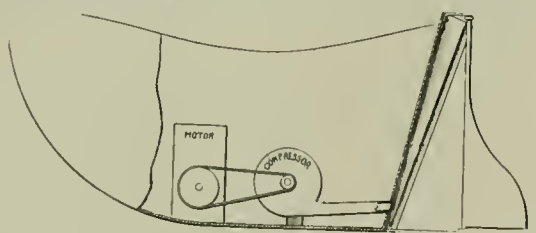
Claim.—4. Means for disengaging a boat from its falls consisting of pivoted hooks, arms on the backs of said hooks and integral therewith, rollers mounted on said arms, cams engaging said rollers, cranks connected



to said cams, a double crank-arm pivoted in its center, connecting-rods between said cranks and opposite sides of said crank-arm, a handle for rotating said crank-arm, and means for locking said handle. Four claims.

808,634. VESSEL-PROPELLING DEVICE. PEET CARLSON, MANOR, TEXAS.

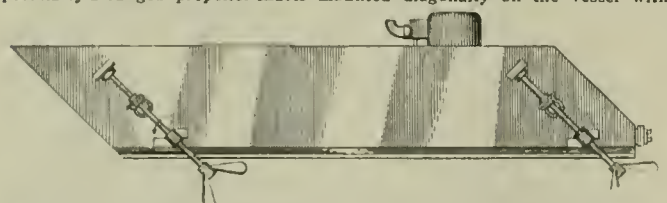
Claim.—1. A vessel having a transversely concaved stern, the side walls of the vessel being extended rearward to form flanges at the opposite sides of said concaved stern, said flanges being arranged on convergent lines



that taper from the upper portion of the stern to a point of convergence adjacent to or below the keel, a discharge-port formed in the stern at a point adjacent to the keel, and means for forcing a stream of compressed air through said port. Two claims.

809,064. MARINE VESSEL. JOHN E. JOHNSON, ISHPEMING, MICHIGAN.

Abstract.—The object of this invention is to provide means for propelling marine vessels which will at the same time decrease the resistance offered by the hull to this propulsion. In attaining this end are provided peculiarly-arranged propeller-shafts mounted diagonally on the vessel with



respect to the water-line and carrying propellers at their lower ends, so that upon the rotation of the shafts the propellers exert a combined lifting and propelling force on the hull, causing it to displace less water, and consequently enabling it to be driven with less resistance. Two claims.

810,032. PROPELLER. ALEXANDER T. BROWN, SYRACUSE, NEW YORK.

Claim.—1. The combination with the shaft of a reversible propeller, of the divided hub, the reversible blades pivoted between the front and rear sections of the hub and provided with the cranks, the sliding head movable lengthwise of the shaft and having flanges contiguous to the cranks, pin-and-slot connections between the cranks and the flanges, said flanges being situated in planes tangential to the shaft, and each crank rotating in a plane parallel with and closely adjacent to a flange, said plane cutting the proximate flange transversely near its base. Fourteen claims.

810,042. MOORING DEVICE. WILLIAM D. DUNCAN, BOSTON, MASSACHUSETTS.

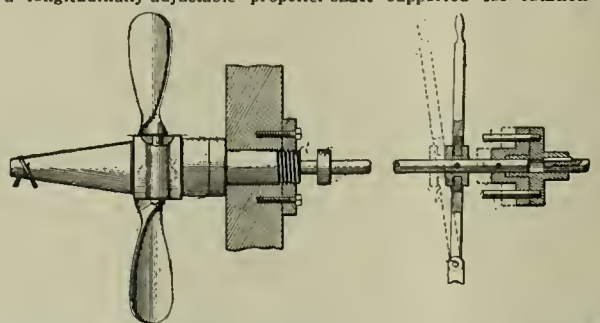
Claim.—A mooring device provided with a drum and adapted to have one end of a hawser connected therewith, combined with a cable connected with said drum, and means to move said cable, said cable when moved causing the mooring device to disengage itself from the hawser. Five claims.

810,185. COVER FOR SHIPS' HATCHWAYS. HENRY BURRELL, GLASGOW, SCOTLAND.

Abstract.—The cover of the hatchway or opening is made in the form of a door or doors of iron, steel, or other suitable material, which may be hinged at the ends or sides of the hatchway or may be portable, as may be most convenient. When fitted to large hatchways, across each door or cover a strong beam or beams is or are provided of such strength as will withstand the weight of any water which may fall upon the cover. The cover is further strengthened by stiffening-bars of angle or other suitable section fitted at right angles to and connected with said beam or girder and extending to the coamings of the hatchway. By this means the cross-beams and fore and aft supports usually fitted under the hatch-covers may be dispensed with, and the opening of the cover or door at once leaves the hatchway entirely clear for working cargo, the cover itself being hinged back on deck or lifted clear of the hatchway. The beam or girder or stiffeners being fitted on the top of the cover when covering the hatchway, the whole internal space in the hatchway itself is left free for the stowage of cargo and a plane surface is provided for working upon when the hatchway is open, which plane surface may also serve as a chute for coal and similar cargoes. Six claims.

811,287. REVERSIBLE PROPELLER. FRANK GRAY, MUSKEGON, MICH.

Claim.—1. A reversible propeller-wheel comprising adjustably-mounted blades, the blades being mounted on an axially-adjustable and rotary head, and a longitudinally-adjustable propeller-shaft supported for rotation and



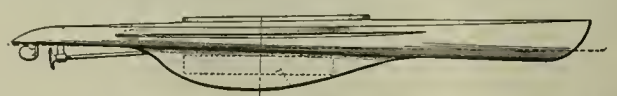
connected for reversing said blades together with a stationary member having an annular groove engaged by portions rigid with the said blades. Twelve claims.

811,815. LIFE-SAVING BOAT. AUGUST BAUMGART, LIND, WASH.

Abstract.—The object of the invention is to provide a life-boat so constructed that the force of the waves shall be compensated in striking the life-boat, so that the force of the waves and the water will be wholly expended upon an outer movable cover to protect the life-boat proper; and a further object is to provide a means whereby the approximately barrel-shaped housing or outer cover may be permitted to revolve freely with the wash of the water or the movement of the waves; and the still further object is to prevent the longitudinal movement of the approximately barrel-shaped housing or cover. Seven claims.

811,887. HIGH SPEED MOTOR BOAT. THOMAS WHELESS, NEW YORK.

Claim.—6. A high-speed motor-boat having fine lines below the water-

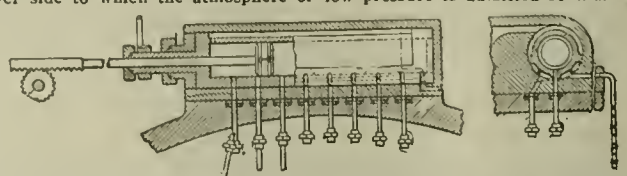


line and having buoyancy-chambers provided at each side above the water-line and tapering upward and outward and also being inclined downward

from the bow aft, and being provided with a hollow keel weighted at its base and opening upward into the boat. Ten claims.

811,987. MARINE TURBINE. JAMES WILKINSON, BIRMINGHAM, ALA., ASSIGNOR TO WILKINSON TURBINE COMPANY, A CORPORATION OF ALABAMA.

Abstract.—An object of this invention is to provide an improved controller-valve that will be held to its multiported seat in a manner to prevent any leakage of pressure around the same. To this end the valve is exposed above to a high pressure and has one or more channels or recesses on its lower side to which the atmosphere or low pressure is admitted so that the



valve is thus unbalanced to an extent that will cause it to be held very firmly to its seat. According to this construction high pressure is used to open the turbine valves, which are closed by springs or other constant pressure acting against them or their motors, when either is exposed to low pressure by the controller valve. Twenty-six claims.

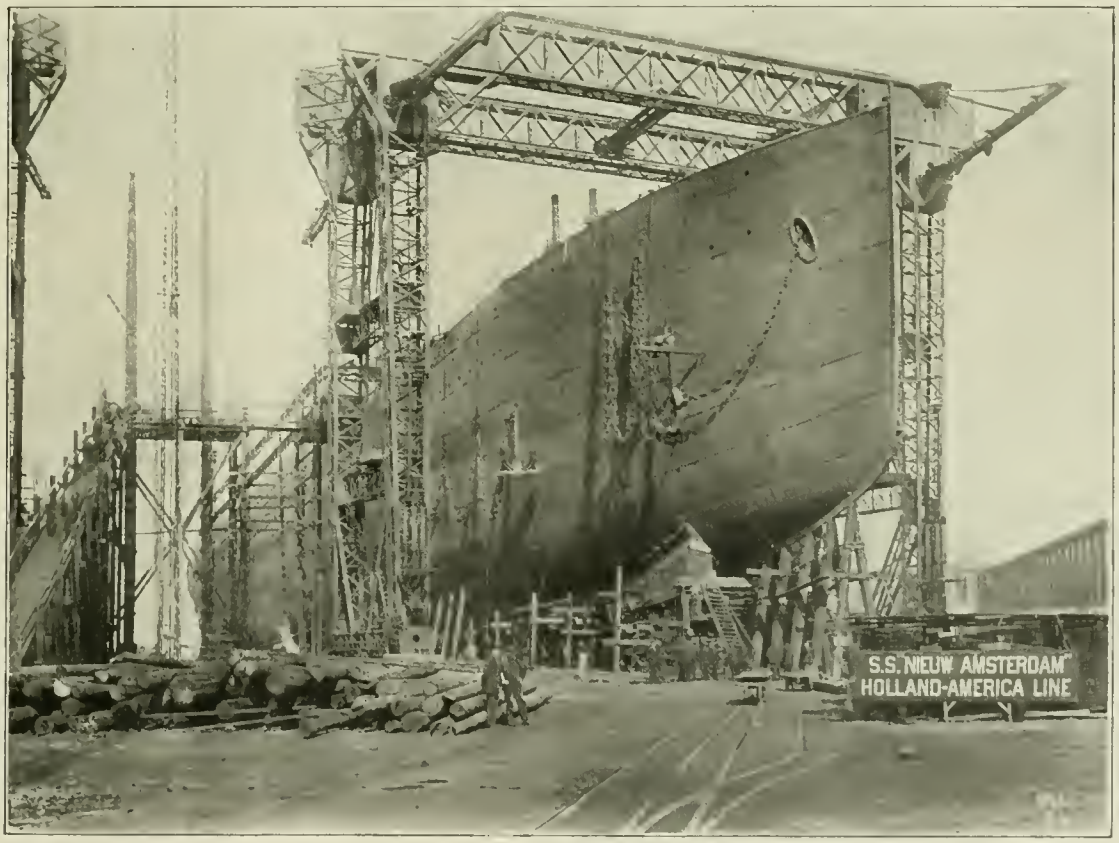
International Marine Engineering

JUNE, 1906.

THE HOLLAND-AMERICA LINER NIEUW AMSTERDAM.

This latest production of the Harland & Wolff shipyard, Belfast, which was launched September 28, 1905, reached New York on the afternoon of Monday, April 16, after a voyage which began at noon, April 7, at Rotterdam. The time of passage from pier to pier was about nine days and nine hours. The daily runs on this her first voyage ranged from a maximum of 395 nautical miles to a minimum of 314. The larger distance was covered at a mean rate of 16.45 knots continued through twenty-four hours, while the voyage for the entire trip was a little better than 15 knots, which is a very creditable performance.

Five decks have been set apart for the accommodation of passengers, the principal apartments being located centrally and far above the water. The decorative treatment of the interior is decidedly novel and very attractive. In most instances the style used is Dutch from various periods, with panels giving views both in Holland, and in New Amsterdam as it existed during the time of the Dutch governors, the wood work being invariably light in color, thus lending an air of lightness and grace to the entire scheme of decoration, in place of the dark and heavy effects so common in steamship work.



BOW VIEW OF THE NIEUW AMSTERDAM, BEFORE LAUNCHING.

The *Nieuw Amsterdam* has a length between perpendiculars of 600 feet, a length over all of 615 feet; a beam of 68 feet 6 inches; and a depth of 48 feet. The gross registered tonnage is 16,913, with a net tonnage of 10,687, and a displacement at load draft (35 feet) of 31,150 tons. The dead weight carrying capacity is about 12,000 tons. The ship is rigged as a four-masted schooner. Accommodation is provided for 440 first-class, 246 second-class and 2,200 third-class passengers; besides the crew of 305 men, including 50 in the navigating department, 90 in the engineering department, and 165 in the stewards' department. On the maiden voyage the complement of passengers included 306 in the cabin and 1,982 in the steerage.

The first-class dining saloon is decorated with Austrian oak framing with stamped metal panels, there being overhead a pleasing dome with art plaques representing the seasons, and with medallions carrying relief representations of state and municipal arms. Among the latter might be mentioned the arms of Holland, of the state of New York, and of the cities of New York, Amsterdam and Rotterdam.

The social hall and music room is situated on the promenade deck and is finished in polished mahogany enriched with gilt bronze empire ornaments. The fireplace at the forward end is constructed of turquoise blue marble and cream colored tilings, a wood fire being represented by means of electric apparatus hidden

behind asbestos logs. The same sort of fireplace is situated in the after end of the first-class smoking room. Above the mantel of the fireplace in the social hall is a large tiled picture illustrating the city of New Amsterdam as it appeared early in the eighteenth century. In this apartment are hung autograph paintings of Queen Wilhelmina and the Prince Consort. In the equipment are included an organ and a Steinway grand piano. The entrance from the promenade deck is finished in teak and birdseye maple, surmounted by an ornamental glass dome.

NIEUW AMSTERDAM AFLOAT, SEPTEMBER 28, 1905.

One of the most prominent novelties on the ship is the Japanese tea room, located in the center of the promenade deck, and connecting, by means of a short passage, with the smoking room.

STERN VIEW JUST BEFORE LAUNCHING.

The decoration consists of Japanese art panels in polished satinwood, with black inlaid lacquer work, while the ceiling is decorated with paintings on linen. During the day, light is admitted through a dome of tinted and painted glass, while at night illumination is supplied by suspended Japanese lamps fitted with electric lights. The fireplace is of black lacquered marble with painted tilings; the floor is covered with rubber tilings. Tables and chairs are Japanese in style.

The first-class smoking room, which is aft of the tea room, is a broad apartment with a thoroughly Dutch decorative scheme finished in fumed oak, with Palissander wood inlays, and tiles from the famous Dutch art potteries. A Belgian marble mantelpiece at one end is decorated with old Dutch tiles, the furnishings throughout the apartment being Dutch in every respect.

The first cabin staterooms are situated on the upper, the saloon and the bridge decks. They are very spacious and are fitted to accommodate two or three passengers. In many cases the disadvantage of having an inside room is done away with by the fitting of tandem staterooms. The staterooms on the bridge deck are especially large, and include a number of suites or cabins de luxe which are fitted in many cases with brass bedsteads in place of the customary steamer berths.

The second cabin staterooms are located on the upper deck, aft of the first cabin accommodation, and are finished in similar style, though less elaborately. The second-class dining saloon, which is on the saloon deck aft, extends the full width of the ship and has a dome ornamented with colored glass. Above this dining saloon are the second cabin ladies' room, and the smoking room, both of which are finished in light colored hard woods with inlaid decorations.

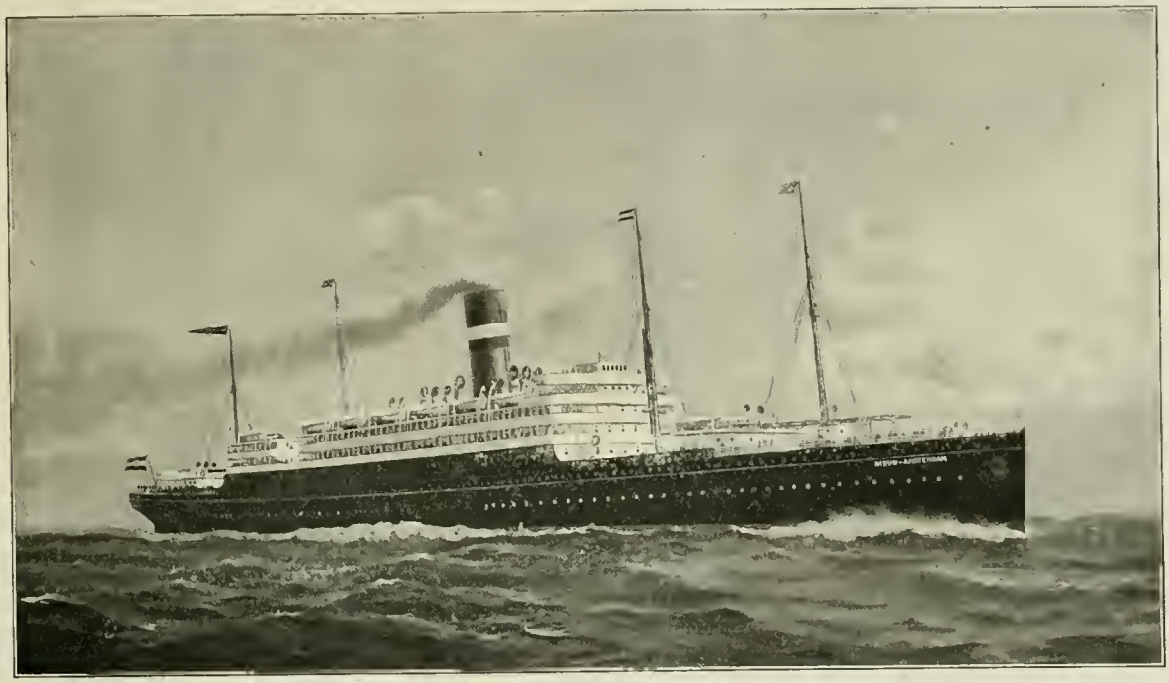
One of the notable features of the ship, and one which will commend itself to passengers, is the breadth and extent of promenade space on the promenade deck. An unusual amount of such space has been provided, there being no less than 8,200 square feet on this deck, 4,440 square feet on the bridge deck and 5,000 square feet on the boat deck. The promenade facilities provided for second cabin passengers are also ample.

The hull construction is, of course, entirely of steel, with a double bottom extending the full length of the ship. The hull is divided by twelve transverse bulkheads reaching to the upper deck into thirteen watertight compartments, this including the watertight bulkhead separating the two sets of boilers.

SCANTLINGS.

The frame spacing throughout is 30½ inches. For the greater part of the length of the ship the frames are channels measuring 9 by 4 by 4 by 13-20 inches, while forward and aft angle bars are used, 9 by 4 by 12-20 inches, with reverse frames 4 by 4 by 12-20 inches. The deck beams up to and including the saloon deck are channels 10 by 4 by 4 by 11-20 inches, while above this are fitted

bulb angles measuring 7½ by 3½ by 10-20 inches The floor plates, which extend in each case from margin plate to margin plate, measure 12-20 and 11-20 inches respectively amidships and at ends. They are fastened to the bottom plating by angles 4 by 4 by 12-20 inches amidships, and 4 by 4 by 11-20 inches at the ends.



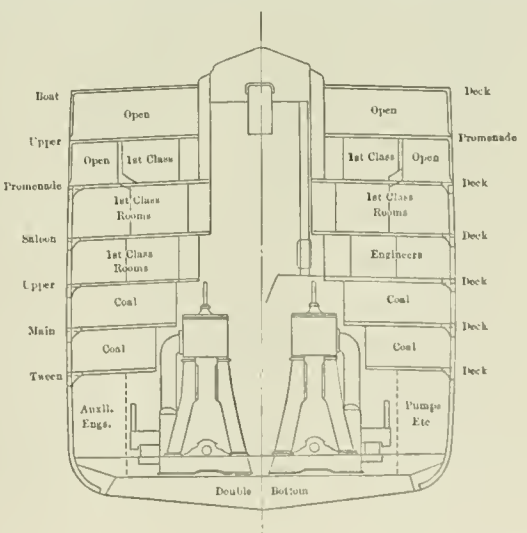
THE STEAMSHIP NIEUW AMSTERDAM AT SEA.

A flat keel plate is fitted, 23-20 inch thick, with a flat rubbing piece outside, measuring 12 by 3 inches. The garboard strake is 20-20 inches amidships, while the next five bottom strakes measure each 18-20. The four bilge strakes measure 19-20 inch, while the two strakes at the sharpest part of the turn of the bilge have liners of the same thickness. The six strakes next above the bilges measure 19-20 inch in outside courses and 18-20 inch in inside courses. Above this, the inner and outer courses are respectively 19-20 and 20-20 inch, while the sheer strake, 1 inch thick, is backed up by a liner of the same thickness. The sheer strake proper is 59 inches wide, its doubling or liner strake having the same width. The strake immediately below is 37 inches wide, while the liner, of 19-20-inch plate, is 50½ inches wide. In each case the lap measures 6¾ inches. The side plating above the saloon deck is 12-20 inch thick.

The center line vertical keelson measures 56 inches wide and 16-20 inch thick. Fore-and-aft plates forming margins of the double bottom are 15-20 inch thick amidships and 13-20 at ends. The tank top consists of plates 12-20 inch thick in general, with thickness increased to 13-20 inch in engine and boiler rooms. Side stringers above the turn of bilge consist of 15-20-inch plates amidships, each fitted with a continuous angle bar running along channel framing and measuring 6½ by 4½ by 12-20 inches amidships and 11-20 inch thick forward and aft; a continuous angle bar turned down over the inboard edge, 6½ by 4½ by 15-20 inches amidships and 14-20 inch forward and aft; and intercostal angles connecting with side plating. Fore-and-aft channels are fitted at about the quarter width under the deck beams of platforms, 'tween decks, main, upper and saloon deck, being in all cases 7 by 3½ by 3½ by 10-20 inches.

Additional fore-and-aft longitudinal stiffness is assured by 15-20 inch stringer plates on platforms and 'tween decks, with 14-20 inch plates in the next strake and the balance of the steel decks in each case 7-20 inch thick. The main deck and upper deck have stringer plates 18-20 inch thick, with the next strakes 17-20 and 18-20 inch respectively, and with complete steel decks 10-20 and 12-20 inch thick respectively. The saloon deck has a stringer plate 19-20 inch thick, the next two strakes being 18-20 and the balance of the steel deck 13-20 inch. The promenade deck, which does not contribute very heavily to the longitudinal strength, has a stringer plate 10-20 inch, the balance of the complete steel deck being 6-20 inch thick.

From the double bottom to the upper deck, throughout the central portion of the ship, is a bulkhead of $\frac{5}{16}$-inch plating, with vertical stiffeners acting also as stanchions at the center line. These stanchions, up to the 'tween deck, are channels measuring



TRANSVERSE SECTION, SHOWING ACCOMMODATIONS.

8 by 3½ by 3½ by 11-20 inches; with 4 by 3 by $\frac{7}{8}$-inch angles on the back. From 'tween deck to main deck the channels measure 7 by 3½ by 3½ by 10-20 inches, while above the main deck are fitted 6 by 3 by 10-20-inch bulb angles. In each of these latter cases, moreover, additional stiffening is provided by 3½ by 2½ by ⅜-inch angles. Above the upper deck are stanchions

3½ inches in diameter and spaced 5 feet 1 inch apart. The quarter stanchions below the platforms are 5 inches in diameter; between platforms and 'tween deck, 4⅝ inches; from 'tween deck

THE MUSIC ROOM AND SOCIAL HALL.

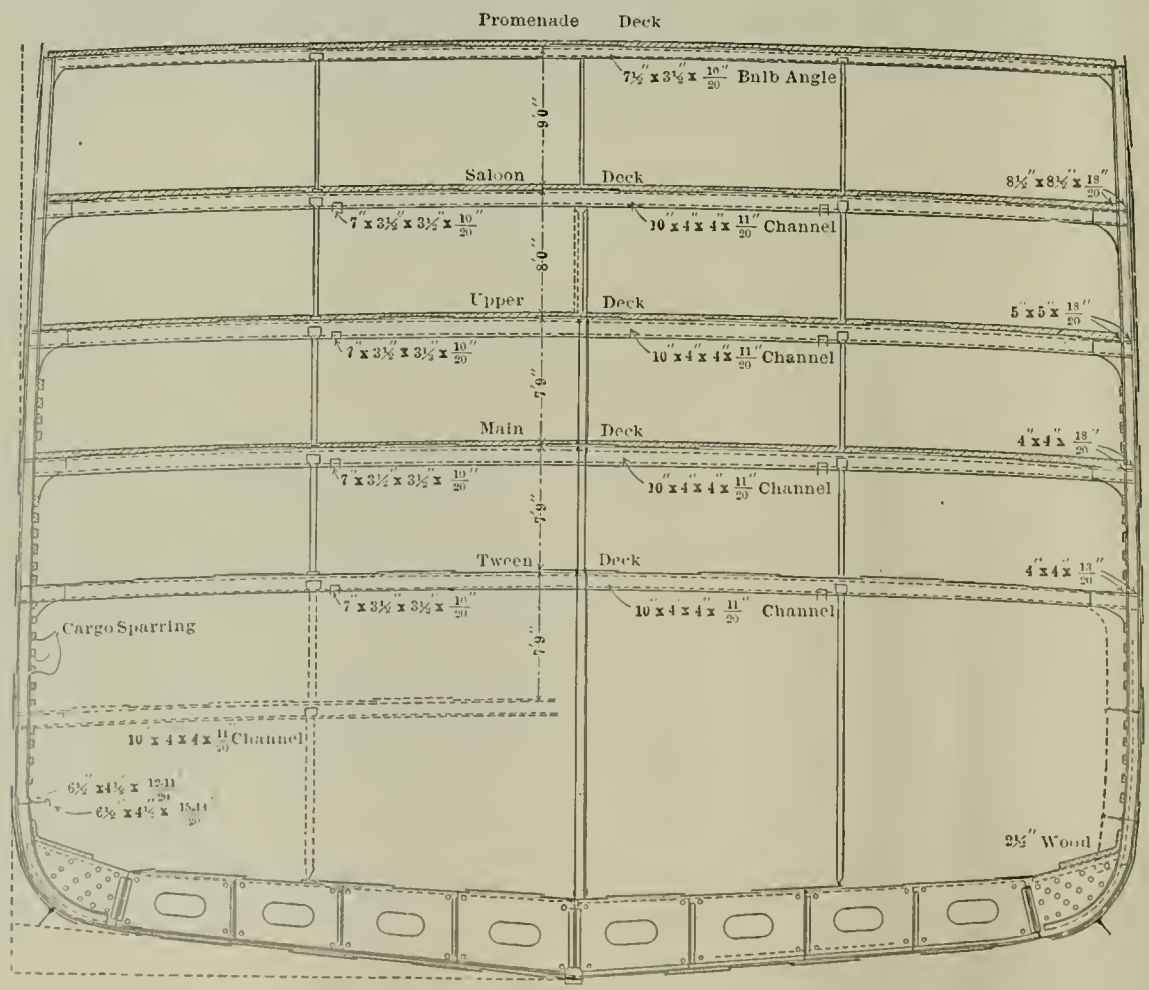
to main deck, 4⅜ inches; from main deck to saloon deck, 3½ inches; and from saloon deck to promenade deck, 3¼ inches. All

Wood deck planking is fitted on main, upper, saloon and promenade decks, being of 5 by 3-inch material on the main deck; 5 by 3½-inch pitch pine on the upper deck; 5 by 3½-inch yellow pine on saloon deck and 4 by 3-inch yellow pine on promenade deck. The deck spacing from top of beam to top of beam measures 7 feet 9 inches from platform to 'tween deck, 'tween deck to main deck and main deck to upper deck. From upper deck to saloon deck it is 8 feet, and from saloon deck to promenade deck 9 feet.

The double bottom measures 4 feet 8 inches deep in the center of the ship, and is fitted with fore-and-aft watertight bulkhead. It has a total capacity for ballast and feed water of 2,810 tons, while the tank fitted for drinking water has a capacity of 800 tons. In addition to this, the lower part of hold III is fitted as a deep tank, with a capacity of 1,330 tons of water, the space being also available for cargo. Adding the capacities of the fore and aft peaks, the total water capacity of the ship is 4,200 tons.

PROPELLING MACHINERY.

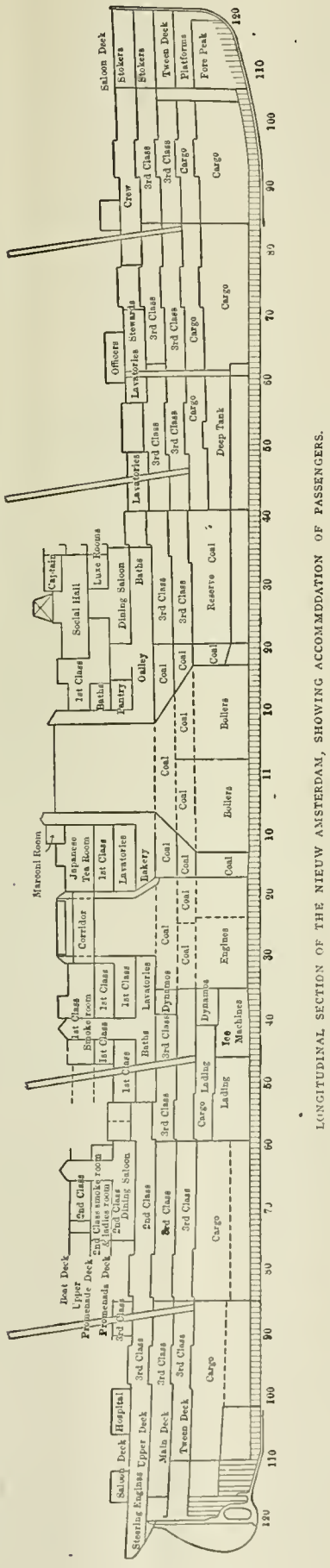
The ship is propelled by twin screws actuated by two quadruple expansion engines of the usual vertical inverted direct acting type, balanced upon the improved Yarrow-Schlick-Tweedy system and capable of developing each about 5,200 indicated horsepower at 80 revolutions per minute. The cylinders measure respectively 29, 41½, 61 and 87 inches in diameter, with a common stroke of 60 inches. The cylinder positions from forward are: high-pressure,


Promenade Deck
7½" x 3½" x 10/20" Bulb Angle
9'0"
Saloon Deck
8½" x 8½" x 18/20"
7" x 3½" x 3½" x 10/20"
10" x 4" x 4" x 11/20" Channel
8'0"
Upper Deck
5" x 5" x 18/20"
7" x 3½" x 3½" x 10/20"
10" x 4" x 4" x 11/20" Channel
7'9"
Main Deck
4" x 4" x 18/20"
7" x 3½" x 3½" x 10/20"
10" x 4" x 4" x 11/20" Channel
7'9"
Tween Deck
4" x 4" x 13/20"
7" x 3½" x 3½" x 10/20"
10" x 4" x 4" x 11/20" Channel
7'9"
Cargo Sparring
10" x 4" x 4" x 11/20" Channel
6½" x 4½" x 12-11/20"
6½" x 4½" x 18-11/20"
2½" Wood

MIDSHIP SECTION OF THE SHIP, SHOWING FRAMING AND DECK BEAMS.

are spaced 7 feet 7½ inches apart. Over the portions of the ship not provided with platforms the quarter stanchions extend from tank top to 'tween decks, and are 5½ inches in diameter.

second intermediate, low-pressure, first intermediate. The crank sequence shows high-pressure, first intermediate, second intermediate and low-pressure, with angle between high-pressure and



LONGITUDINAL SECTION OF THE NIEUW AMSTERDAM, SHOWING ACCOMMODATION OF PASSENGERS.

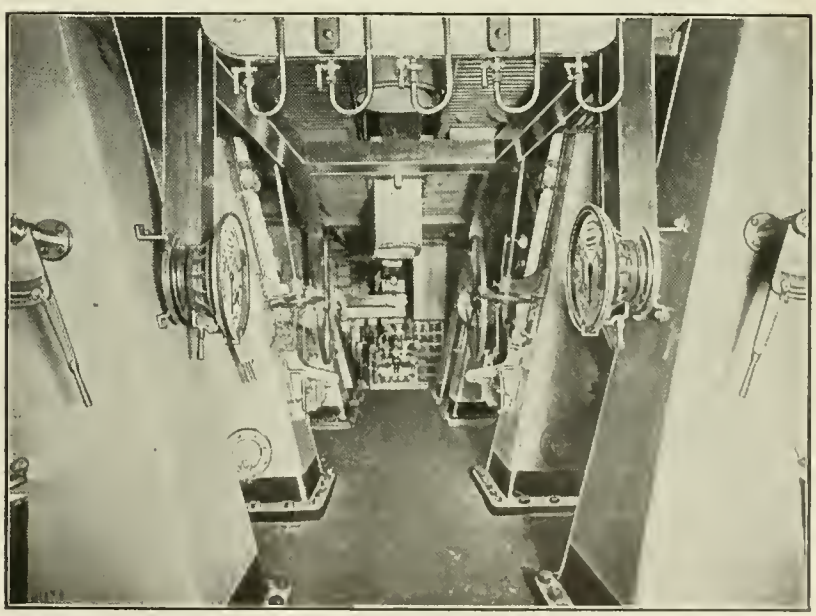
first intermediate 62 degrees; between first and second intermediate cylinders, 96 degrees; 106 degrees from second intermediate to low-pressure, and then 96 degrees completing the cycle back to the high-pressure cylinder.

The high-pressure and first intermediate cylinders have each one piston valve, the second intermediate cylinder is served by two such valves, and the low-pressure cylinder by a large slide valve with balance piston on top. All of the valves are actuated

A CORNER OF THE JAPANESE TEA ROOM.

by means of eccentrics operating with Stephenson link motion of the double bar type. The high-pressure and first intermediate pistons and valve rods pass through glands using United States metallic packing. All of the pistons of the main engines are provided with Lockwood and Carlisle's piston springs.

The shafting, all of which is made of Siemens-Martin steel, has a total length of 252 feet 6¼ inches. The crank pin diameter is 18 inches, crank shaft 17½ inches, thrust shaft 17¼ inches,



THE STARTING PLATFORM IN THE ENGINE ROOM.

line shaft 16½ inches and propeller shaft 17¾ inches. There are eight collars on the thrust shaft, the total thrust surface being 2,020 square feet. The propellers, which are three-bladed, and of manganese bronze, have a diameter of 18 feet 6 inches and a pitch of 23 feet; a pitch ratio of 12.42 being thus obtained. The developed surface of each propeller is 843¼ square feet.

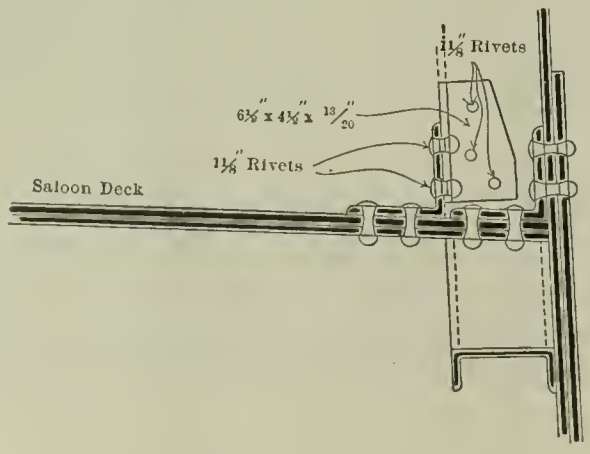
The two main engines are in a single engine room without center line bulkhead, the starting platforms being conveniently located between the engines, and in plain view of the telegraphic signals from the bridge. The entire outfit has ample space for the use of the engine room crew, without the crowded conditions so often noticeable on transatlantic ships. The main engines are supported upon hollow cast iron box columns, eight in number for each engine, the condensers being incorporated with the back columns. The front columns are utilized for oil storage,

THE DUTCH FIREPLACE IN THE SMOKING ROOM.

and are provided with taps for drawing off oil as needed. The main steam pipes are all of wrought iron, lap-welded, with flanges welded solid to the pipes.

BOILERS.

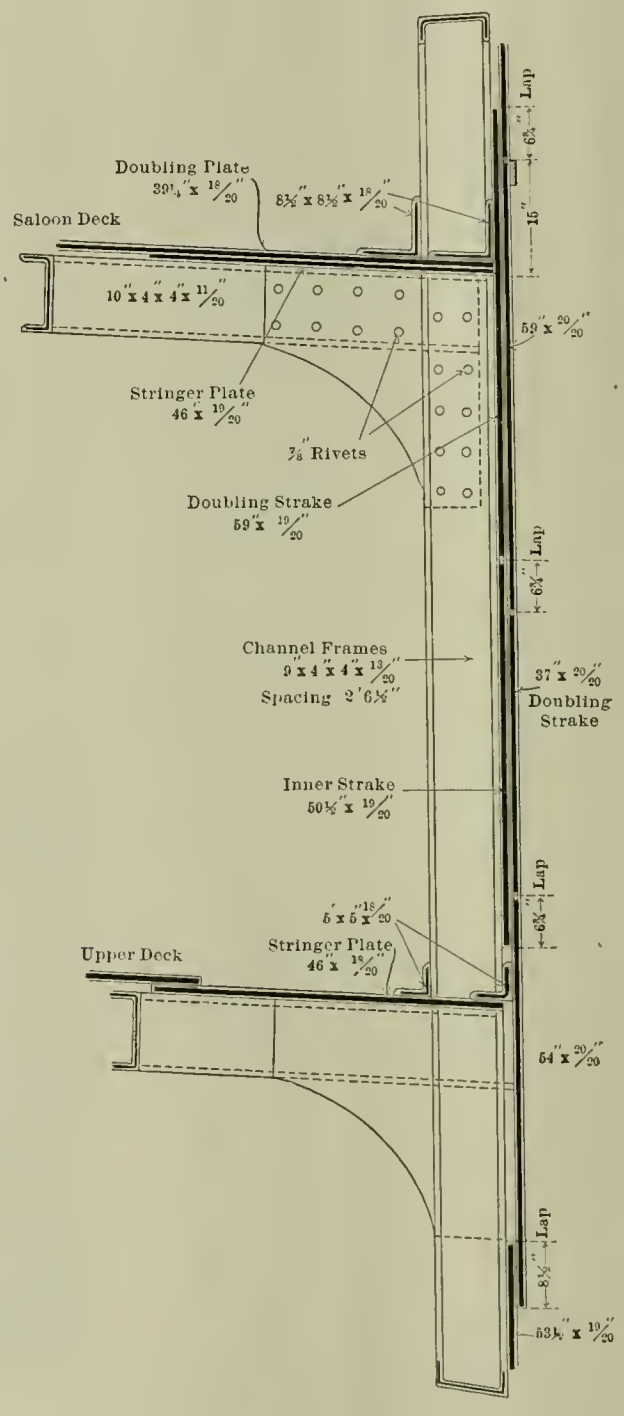
There are seven steel double-ended boilers of the familiar Scotch or cylindrical type, operating at a pressure of 215 pounds per square inch. These boilers are located in two boiler rooms, separated by a watertight bulkhead to the level of the main deck, or well above the water line. The forward boiler room contains three boilers side by side, with a fire room at each end, while the after boiler room has four boilers similarly situated. The products of combustion from all of the seven boilers go into a single stack.



DETAIL SHOWING STRINGER CONNECTION TO SHEER STRAKE.

Each boiler has three furnaces in each end, making a total of forty-two fires. The boilers have a mean diameter of 15 feet, a length of 19 feet 6 inches and are fitted with shells of a thickness of 1 29-32 inches. Each boiler has 732 tubes of a diameter of 2¼ inches. The furnaces, which are of the Purves type, have grates 5 feet 6 inches long and 3 feet 6⅞ inches wide; this gives a grate surface per boiler of 118 square feet, and a total of 826 square feet; while the heating surface in each boiler figures out at 4,543 square feet, and the aggregate heating surface, 31,801 square feet; the ratio being 38.5 to 1.

The funnel is of elliptical section, and consists of inner and outer tubes with air space of 10½ inches between them. The outer tube has a long diameter of 17 feet 1 inch and a short diameter of 13 feet 5 inches, while the inside tube has similar dimen-



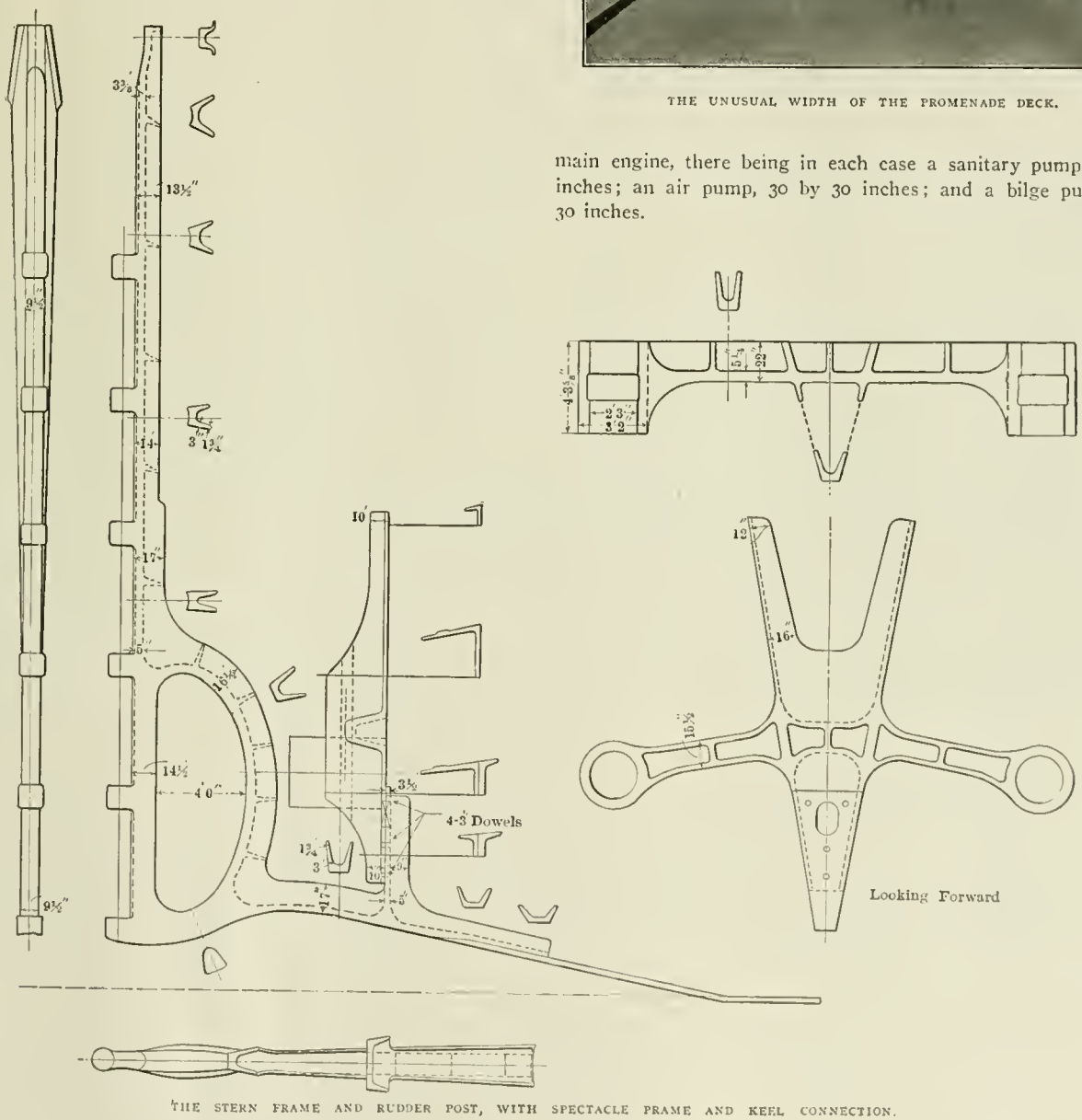
THE GENERAL CONSTRUCTION OF THE UPPER SIDES.

sions 15 feet 4 inches and 11 feet 8 inches respectively. The height of the funnel above the grates on wing furnaces is 118 feet 2 inches. Natural draft is used, but two fan engines are fitted for ventilation, and for slight induced draft when necessary.

AUXILIARY MACHINERY.

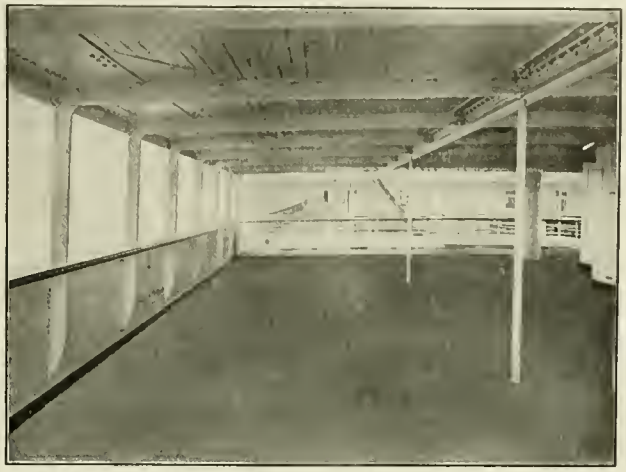
The two main condensers have cooling surfaces amounting to 6,430 square feet each, while the auxiliary condenser has a cooling surface of 2,000 square feet. The Weir's pumps on the main condensers have cylinders measuring 15½ and 11½ inches respectively in diameter, with a stroke of 26 inches. For the auxiliary condenser the air pump measures 9 and 15 inches by 12 inches. The circulating pumps in each case are centrifugal, the two for the main condensers being operated each by a steam cylinder of 11 inches diameter and 10-inch stroke with a pump runner 16 inches in diameter; for the auxiliary condenser the engine is 6 by 7 inches with an 8-inch pump runner.

Three duplex pumps are fitted to be used when needed for boiler feed, pumping bilges, operating ash ejectors and as sanitary pumps; each has steam cylinders 10½ inches in diameter with water cylinders 7 inches and with stroke of 12 inches.



THE STERN FRAME AND RUDDER POST, WITH SPECTACLE FRAME AND KEEL CONNECTION.

Four other duplex pumps are fitted, two for sanitary purposes having cylinders 8 and 9½ inches by 10 inches, while the other two, which are used for pumping drinking water from the tanks in the double bottom, measure 5¼ and 4 inches by 5 inches. The two ballast pumps measure respectively 14 and 15 inches by 14 inches and 12 and 10 inches by 14 inches. In addition to these independent pumps, there are six pumps connected to the main engines, and operated by means of beams whenever the main engines are running. Three of these are fitted to each



THE UNUSUAL WIDTH OF THE PROMENADE DECK.

main engine, there being in each case a sanitary pump, 5 by 30 inches; an air pump, 30 by 30 inches; and a bilge pump, 6 by 30 inches.

The two starting engines have each two cylinders 7½ by 7½ inches. The turning engines have each two cylinders 7 by 7½ inches; the two Wilson and Pirrie steering engines have each two cylinders, 13 by 14 inches; the anchor engine has two cylinders, 15½ by 16 inches. Other engines include that for the ash hoist, which measures 5 by 7½ inches; a mooring engine aft, measuring 10 by 16 inches; two fan engines in the stoke hold,

each 6½ by 5 inches; and fourteen cargo winches, 8 by 11 inches.

There are two refrigerating engines operating on the J. & E. Hall carbonic acid system, one having a compound engine, 7 and 14 by 9 inches, while the other has a simple engine 8 by 9 inches. From these engines the refrigerant is circulated through the various compartments as needed. The feed filter is of the Raylton & Campbell pattern, while a Quiggins feed heater is installed. The Weir's evaporator has a capacity of 50 tons per day, while two distillers are fitted, with a capacity of 20 tons each.

THE EQUIPMENT.

The ship is lighted throughout by electricity, which is also utilized for heating purposes in a number of public rooms and in the suites de luxe. This electricity is generated by four dynamos supplied by William H. Allen, Sons & Company, of Bedford, England. The engines driving these generators are compound, with cylinders 9 and 15 inches in diameter and a stroke of 9 inches, and are coupled direct to the multipolar dynamos, which operate at 110 volts at a speed of 300 revolutions per minute, the output of each dynamo under full load being 263 amperes. All of the machines are placed aft of the engine room, three being immediately over the thrust bearings, while the fourth is above the water line. The main switchboard is placed alongside the three machines, while an auxiliary board is fitted near the other. The total number of lights utilized is about 1,500, while electricity is used for a great many other purposes, including ventilating fans, telephones, a complete bell system, etc. There is also a wireless telegraphy equipment on the Marconi system fitted in a special house on the boat deck.

The equipment includes Hall's patent anchors, weighing 6,700 kilograms (14,750 pounds) each, with 3¼-inch anchor chains. The mooring anchors aft weigh each 2,600 kilograms (5,730 pounds) with 2-inch chains. The total number of lifeboats is twenty-four, of which eighteen measure 28 feet 6 inches by 8 feet 6 inches by 3 feet 6 inches; four measure 28 feet 6 inches by 8 feet 6 inches by 2 feet 6 inches; and the other two are 24 feet by 6 feet 6 inches by 2 feet 6 inches. The rudder stock has a diameter of 15 inches, while the framing consists of four sections with broad horizontal palms for connecting each to the next. These palms have a thickness ranging from 2½ to 3½ inches over the various portions. The rudder is hung from six pintles.

For many of the structural details and the drawings we are indebted to *De Ingenieur*.

Steamship Earnings.

The Cunard Steamship Company reports for the calendar year 1905 gross earnings amounting to $8,866,340 as against $7,443,800 for 1904. This increase of $1,422,540 represents a gain of 19 percent. The year as compared with the previous one was much better, however, than these figures would indicate, because of the fact that the net earnings increased from $748,195 in 1904 to $1,533,000 in 1905, this increase being 110 percent. In place of no dividend at all in 1904 a dividend of 4 percent was declared in 1905; after charging to reserve in the latter year the sum of $234,300, an item which did not appear in 1904, a surplus of $35,500 is carried forward to 1906. This statement indicates a very satisfactory condition of the company.

The Hamburg American line, after a very successful year, has paid dividends amounting to 11 percent on the capital stock of $23,800,000. A balance of $270,000 is carried forward to 1906. The company operates 349 vessels, of which 157 are ocean steamers. The aggregate tonnage is 811,943, a figure only slightly less than that of the entire foreign service merchant marine of the United States.

STEEL BARGES.*

BY RICHARD J. DONOVAN.

In opening this discussion I will present some facts concerning river transportation, that we may get some idea of the conditions of service met with in this business. We may divide the business of transportation into two general classes: First, that which pertains to bulk quantities, including such staple articles as coal, steel, grain, etc.; second, that which pertains to package quantities, including the general run of merchandise which may come in some form of package, or in quantities which will not warrant special shipment. We find that, in the case of the first class, viz: bulk quantities, the problem consists in simply loading the article considered in some type of carrier and delivering at some destined river port, without breaking or shifting individual cargoes. With the second class, viz: package freight, there is more or less shifting or breaking cargo, with additions or subtractions at various points.

Of course the handling of bulk quantities is by far the most interesting problem to the engineer, and it is here that the observer is astonished at the magnitude of such individual movements on our rivers. For the benefit of those of us who are not sufficiently acquainted with the volume of traffic on the Ohio river, it may be interesting to present a few facts concerning this matter. The total navigable mileage of the Ohio and all its tributaries is about 4,400 miles, the Ohio itself being about 1,000 miles from Pittsburg to Cairo, where it empties into the Mississippi.

The gross freight movement on this vast waterway system amounts to about 11,000,000 tons per year, the coal from our Pittsburg district constituting about half of this tonnage. In handling this enormous business, there are employed about 480 steamboats of all descriptions, and some 6,000 or 7,000 barges. I might add that one company here in Pittsburg, the Monongahela River Consolidated Coal and Coke Company, owns upward of 100 tow boats of all descriptions together with 3,000 barges, and ships annually about 4,000,000 tons of coal.

The various types of carriers used on this great system may be divided into two classes: First, those provided with their own propelling machinery, such as the stern and side wheel steamboats; second, all carriers that have to be towed or moved by external means, such as the coal barge, or decked merchandise barge. We would here note that there are a large number of craft used in maintaining traffic, such as dredges, snag boats, derrick boats, repair and pump boats, etc., which we will touch on later. These two general classes are the result of many years' experience and hard thought on the part of those engaged in the river business, and the types adopted are peculiarly fitted for the service.

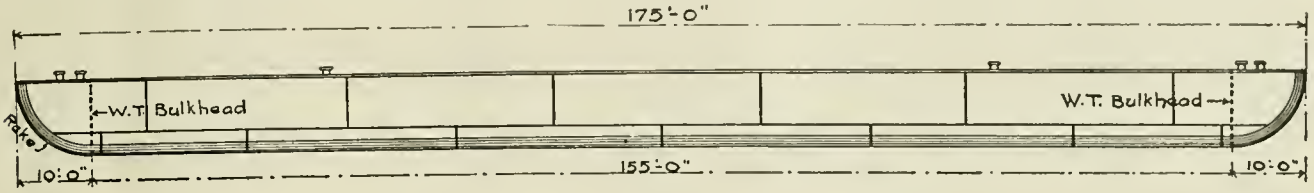
The final result in any design for a carrier on any waterway system is a compromise between adaptability for certain speed, draft of water available and carrying capacity required, there being of course many other details peculiar to the service conditions.

The requirements for a river steamboat then may be briefly stated to be (taking first the case of the packet steamer) such speed as has been found economical for the service engaged in, the least possible load draft, and such freight and passenger capacity as the usual run of business would warrant. In the case of the tow boat, large reserve propelling power is an important item, and due to the fact that coal barges leak more or less, there must be a large excess in boiler capacity for the purpose of operating the steam siphons which are used to keep the tow clear. The under water parts of the tow boat hull are, as a rule, not so fine as a packet boat, that is, they are not formed for such speed. They are not intended to carry cargo,

*Paper read October 24, 1905, before the Engineers' Society of Western Pennsylvania.

and the accommodations provided are generally but little in excess of those required by the crew. The boats are well supplied with all kinds of appliances and machinery for handling the tows, and in the intricate and shallow channels are admirably suited for the purpose intended.

In bulk transportation we have seen that coal is far in the lead as a staple product, and we will now present a short account of the carriers used in this trade. These carriers are divided by the rivermen into two classes known respectively as the "barge" and the "boat", both of which are rectangular in plan and resemble large open boxes. The ends of both are usually curved or raked, from the bottom to the head blocks, as the ends which take the bumps and shocks are called. Bulkheads are fitted in some at each end, separating the rake end from the main cargo space. The barge is mainly used in the Cincinnati and Louisville trade, while the boat is employed almost exclusively in the Mississippi river business. The barge is usually about 135 by 26 by 8 feet, and will carry between 15,000 and 16,000 bushels, or nearly 600 tons, on a draft of about 6 feet 6 inches. The boat is usually about 170 by 28 feet by 8 feet 6 inches, and will carry about 25,000 bushels, or 950 tons.



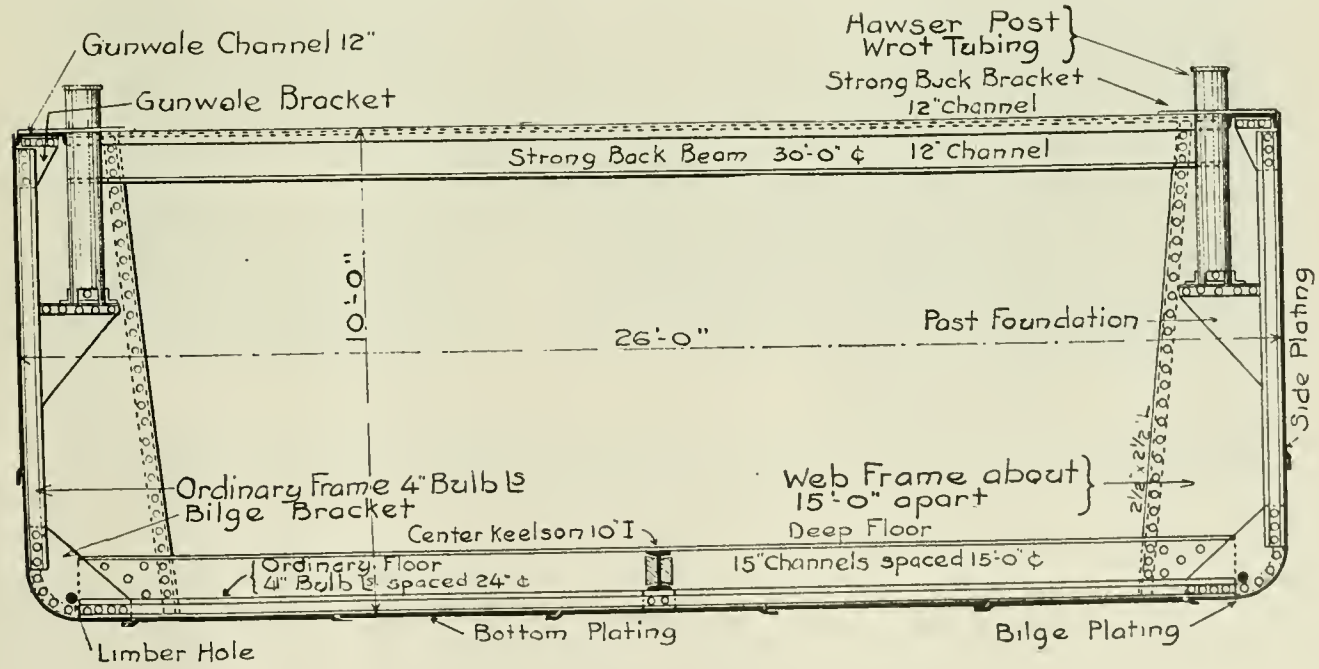
LONGITUDINAL ELEVATION OF STEEL BOAT FOR RIVER TOWING SERVICE.

The barge is built in a very substantial manner and will last for some time, but the boat is merely thrown together and can stand but little hard usage. For some kinds of cargoes, such as sand and bulk merchandise, deck barges are used. These are of various dimensions and built to stand the hardest usage.

There is also a very important business on the Mississippi river in the transfer of railroad cars from side to side. These car ferries or transfer boats are generally of large dimensions and are supplied with their own power. There are also in use a number of transfer barges built in the most substantial manner especially for this business.

Up to the present time, wood has held its own in river construction on account of its cheapness, for the wooden structure costs but one-half to one-third as much as the steel structure. However, suitable timber is becoming very costly on account of its scarcity, and the large operators are beginning to investigate the relative advantage of steel for their transport fleets. At present there are several examples in steel of the various types discussed operating on the Ohio river, and experience has shown that the steel hull is far superior to the wooden hull in low cost of upkeep, while its life is double that of the wooden.

We will now examine the construction of a typical steel river steamboat. The general principle involved in the construction of any type of boat is usually embodied in arranging a longitudinal "backbone" consisting of longitudinal bulkheads, keelsons and stringers. At right angles to the backbone is arranged a system of "ribs" or transverse members, consisting of floors, side frames, deck beams and cross-bulkheads. The shell, or outside plating, is then riveted to the skeleton frame. The



TYPICAL CROSS SECTION OF STEEL BOAT FOR BULK CARGO TRAFFIC

The barge is built in a very substantial manner and will last for some time, but the boat is merely thrown together and can stand but little hard usage. For some kinds of cargoes, such as sand and bulk merchandise, deck barges are used. These are of various dimensions and built to stand the hardest usage.

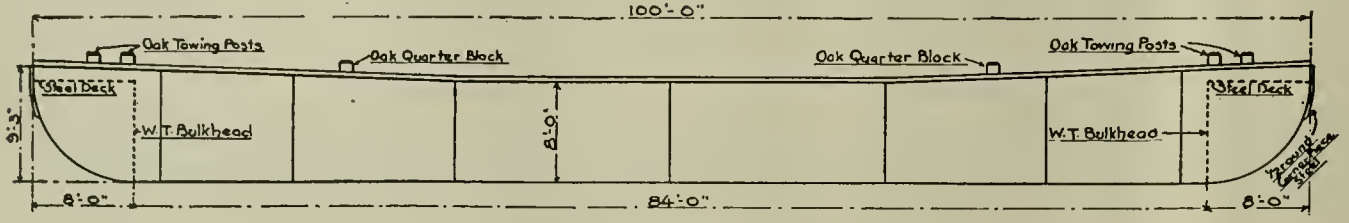
There is also a very important business on the Mississippi river in the transfer of railroad cars from side to side. These car ferries or transfer boats are generally of large dimensions and are supplied with their own power. There are also in bulkheads and shell plating are fitted watertight, this being accomplished by proper spacing of rivets and judicious use of calking tools. Some very interesting construction is required to insure watertightness, but as a rule, in shallow draft river crafts, the water pressure is so low that it is not at all difficult to solve the problem. A complete, or partial, steel deck is usually provided, and on this steel foundation the wooden cabin and upper works are built.

There is also usually provided a "hog chain system" to insure longitudinal strength. This is a truss arrangement

consisting of a square or round section rod carried over tube or timber bracing and leading from the bow of the boat to the stern. It usually projects above the cabins and is quite prominent. The aim is to make the structure as light as possible consistent with the required stiffness and strength for the service conditions.

The following general description refers to a type of steel coal barge of which a number have been built and are now in use.

The steel plating used in these barges is all about ¼ inch in thickness, and the ribs consist of channels and angles fitted alternately, except the side frames, which are angles. A steel



OUTBOARD PROFILE OF STEEL BARGE, AS USED ON THE OHIO RIVER.

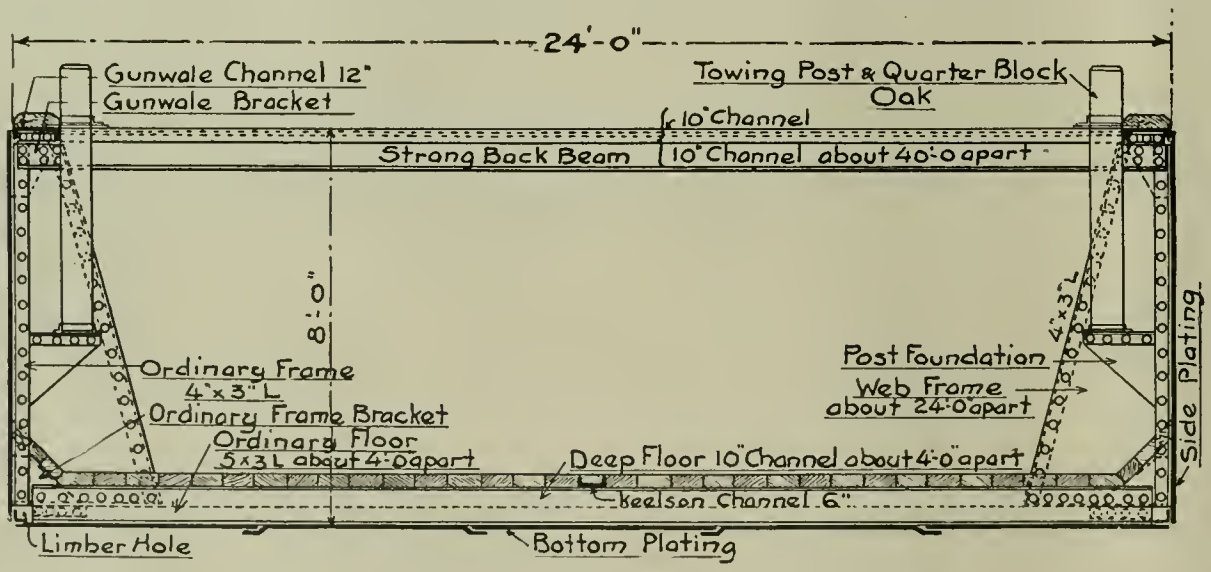
It is perfectly feasible to make an analytical study of the structure of a boat, but in river work such an investigation, using the sizes and sections fitted in the best work of this kind, would show a most amazing confidence in steel, and would probably deter the exact scientific engineer from competing in this line of work. The tow boat hulls are made much stronger than the packet boat hulls, since they have to stand much harder usage in every way, besides carrying much heavier machinery.

Now let us consider a steel open "boat" or "barge" for the transportation of coal. The same principle is carried out here as in the case of the steamboat hull—viz, the backbone and rib

watertight bulkhead is fitted at each end of the cargo space, and a steel handling deck is arranged from top end of bulkhead to head block. A heavy channel is fitted at the top of the side plating for lateral stiffness, and strong beams are fitted across the open cargo space at the quarter block or hawser posts. As the clamshell, or unloading bucket, is used in taking out the coal, a wood flooring, or ceiling, is laid on the channel floor beams, thus presenting a smooth surface for the unloader.

These barges have given good satisfaction to the owners and are said to hold about 80 tons more coal than the wooden barge of the same dimensions and draft.

In the construction of steel deck barges, care must be taken



CROSS SECTIONAL ELEVATION OF STEEL BARGE FOR RIVER FREIGHT SERVICE.

construction—but here we have to depend more on the sides of the boat or barge acting as the backbone or longitudinal girder—for the interior or hold space must be available for cargo. The ends are usually curved up to heavy end construction known as the head block, which takes the bumping and blows incident to the rough service. This curved part is called the "rake" by rivermen, and is introduced to ease the passage of the boat through the water. At the foot of the rake at each end, a watertight cross bulkhead is usually fitted for safety purposes. The framing of the rake must be of a very substantial character, as it is here that the barge suffers most. The ribs are spaced about 2 feet apart in the cargo space, and at certain intervals there are beams fitted across the barge to stiffen the sides. The barge is merely a shell, and of course some judgment must be used in unloading or loading the cargo in order to place no undue stresses in the structure.

to make the internal framing sufficiently strong to care for the general longitudinal stresses, and also for those that are local. The conditions of service met with in dredge hulls are such that usually the local loading and stresses are very high, so that we have to deal not so much with general as with local stiffening; but the general construction of such hulls is identical in principle with that which we have already discussed.

In the matter of upkeep, the preservation of steel plating and framing from oxidization is of the highest importance, and it is here that a great deal of trouble and expense is incurred. Due to there being so many manufacturing plants established on the banks of the rivers forming the Ohio, large quantities of acid matter are drained into the water, giving rise to conditions which are highly injurious to the life of the steel river craft. The use of some good protective paint or covering is imperative, but such a paint is hard to find. There are,

however, some such coverings which seem to hold in check this acid to a marked degree.

At present the business of transportation on the Ohio river is a speculation, depending entirely on the stage of water. The government is working to improve this state of affairs by a series of locks and dams along the whole length of the river. In time, it is hoped, an eight- or nine-foot stage of water will be available the whole year, but it is said that this work will cost nearly $100,000,000 and will require about one hundred years for completion. In the old days before the Civil War, the Mississippi and Ohio rivers were crowded with packets and freighters, and an enormous river business was carried on, but the railroads have now taken over the most of this traffic, and the rivers are lined with the decaying remains of this once vast fleet.

ABSTRACTS OF DISCUSSION.

It is sometimes desirable to have a flexible construction. In car ferries, however, they make the bulkheads of girder construction to stand the strain.

Up to date there are only a couple of steel barges in use, and I understand that the only precaution against the action of the coal is to coat the inside with heavy oil. On some barges that have been built for carrying coal there has been used a special acid-proof paint. Of course the barges have not been in use long enough to judge whether the paint is a sufficient covering to protect it against this action. But it is entirely possible to protect steel against any action arising from the sulphur in the coal.

The steel barge would have to be dried out, or docked, at least once a year for examination and painting. It has been my experience with boats carrying a much larger tonnage than the ones under discussion that this has been sufficient. I think a good graphite paint as good as anything. The wooden ceiling is laid in such a way that it can be taken out. This should be done once a year.

When you have a barge sunk, or grounded, in the channel of the river, it will not be any harder to raise a steel barge than a wooden one. When the wooden barges sink most of them go to pieces. With a steel barge you can bulkhead it up, or put chains under it and raise it that way. They will sink just the same as wooden barges. They will not, however, leak so badly. Wooden barges, after four or five years' use, require a great deal of money to keep them in repair.

In winter time, for running through ice the steel barge is what is wanted. At the present time we have to sheet the wooden barge with iron, and when the ice is heavy we string out the barges, put the boat in the front and back it down. That wears the wheels out. About the second trip we have to rebuild the wheels.

As to the form, a long rake on the boats makes them a little easier to tow, while a round corner as they have on the boats at Ambridge is a great advantage in the lock. If we go in with a full head of steam, as we have to do when there is much wind in order to get the boats in at all, we generally put four barges in the lock at one time. If we strike the lock with a square corner the barge will be thrown around and block the lock, but if there is a round corner, it will slip off.

COMPARISON OF THE FRENCH AND GERMAN NAVIES.

(FROM THE REPORT OF THE FRENCH MINISTER OF MARINE.)
BY J. PELTIER.

During the past year the attention of the French parliament has been called to the considerable increase in the power of the German navy. The English navy is manifestly too superior to the French to furnish any proper element of comparison, and we will confine ourselves to an examination of the two fleets which, but recently of very different powers, have each day become more and more nearly equal: the French navy and the German navy.

THE AMERICAN MERCHANT MARINE; SCENES IN NEW YORK HARBOR.

At the present time there are in France twenty-one battleships, eleven of the first class and ten of the second class; nine armored coast defense vessels, all of slight value; eight armored gunboats; eighteen armored cruisers of the first and second class; thirty-three protected cruisers of all classes; one torpedo depot ship; forty-three torpedo-boat destroyers; nine torpedo cruisers; forty high-sea torpedo boats; one hundred and eighty-two torpedo boats of all classes; twenty-seven torpedo boats allotted to the colonies; six submersibles and twenty-nine submarines.

Germany possesses twenty-four battleships, of which nineteen have been built since 1890; eight armored coast defense ships; twelve armored gunboats; six armored cruisers, entirely new; thirty-six large and small cruisers; ten old torpedo cruisers; thirty-seven torpedo destroyers; seventy-eight torpedo boats; besides a number of submarines under construction and three authorized.

At first view the French navy appears somewhat superior to the German, particularly if we consider the total number of different units, but we must notice that on the side of France the difference consists entirely in a large number of small units. In fact, if we consider solely the large battle units, we find a

number of battleships superior by three in favor of Germany. Table I shows the actual differences existing from the point of view of armament and of speed. This table shows that France has twenty-one battleships against twenty-four, and that of the

TABLE I.

French Battleships	Year	Tonnage	Speed	Battery—Heavy	Mean	Light
Suffren	1902	12,728	16.5	4	18	24
Iéna	1900	12,081	17.4	4	16	22
Masséna	1897	12,316	15.5	4	16	20
Bouvet	1897	12,000	16.5	4	16	20
Carnot	1896	12,146	16.0	4	8	28
Charles Martel	1896	11,881	16.5	4	8	27
Jauréguiberry	1896	11,889	16.0	4	8	28
Charlemagne	1897					
Gaulois	1898	11,280	16.5	4	18	24
Saint Louis	1899					
Brennus	1894	11,370	15.0	3	10	25
Henri IV	1902	8,949	15.0	2	7	14
Hoche	1889	10,997	14.0	4	12	23
Magenta	1892					
Marceau	1889	10,900	14.0	2	8	26
Neptune	1891					
Formidable	1887	11,600	13.8	2	18	28
Amiral Baudin	1886					
Courbet	1885	10,620	13.8	7	11	26
Dévastation	1881			6	10	14
Redoutable	1877	9,372	13.5	8	6	23
Total	21	236,709	15.2	80	260	500

German Battleships	Year	Tonnage	Speed	Battery—Heavy	Mean	Light
Sachsen	1877-99					
Wurtemberg	1878-99	7,400	15.0	6	8	16
Bayern	1878-98					
Baden	1880-97					
Oldenburg	1884	5,743	13.5	8	2	13
Brandenburg	1891					
Kurfürst Friedrich Wilhelm	1891	10,662	16.5	6	14	20
Weissenburg	1891-04					
Wörth	1892-02					
Kaiser Friedrich	1896					
Kaiser Wilhelm II	1897					
Kaiser Wilhelm der Grosse	1899	11,152	18.0	4	30	20
Kaiser Karl der Grosse	1899					
Kaiser Barbarossa	1900					
Wittelsbach	1900					
Wettin	1901					
Zaehringen	1901	11,832	19.0	4	30	20
Mecklenburg	1901					
Schwaben	1901					
Braunschweig	1903					
Elsass	1903					
Hessen	1903	13,200	19.0	4	26	20
Preussen	1903					
Lothringen	1904					
Total	24	258,911	17.6	116	520	457

French only fourteen are of a later date than 1890, even including the *Henri IV*, which belongs really to the coast defense line.

So far as displacement is concerned, the French battleships have a total slightly inferior, without taking account of speed, battery and homogeneity. Here the Germans have an overwhelming superiority. When it comes to speed, France has only a single ship of better than seventeen knots, while five of the German ships make eighteen knots and ten others make nineteen.

Comparing the batteries, France has eighty heavy guns against one hundred and sixteen for the German; in guns of medium-caliber France has only two hundred and sixty against the German five hundred and twenty, and their guns are of greater caliber and have heavier projectiles; in small caliber guns, France has five hundred as against Germany four hundred and fifty-seven, but the battle of Tsushima has decidedly discredited these small guns. The three-pounder gun, which forms the majority of the French small artillery, is considered in all navies as absolutely insufficient in size to be of much value.

When it comes to a question of homogeneity, all that is necessary is to glance at the table. Among the French ships there is almost a total dissimilarity of tonnage, armament and speed; while with the Germans the ships are grouped into classes of the same tonnage, armament and speed. It must be remembered that battleships in all navies are not only the principal force to be relied upon but perhaps the only force.

We will not institute a comparison in the details of the coast defenders. These ships have proved in the Russo-Japanese war to be of very little use, and form a certain amount of impediment to a fleet, which might have very serious consequence in the hour of battle. France possesses one more of this type of ship than does Germany, but the German ships are more homogeneous, better armed, and faster.

TABLE II.

French Armored Cruisers	Year	Tonnage	Speed	Battery—Heavy	Mean	Light
Jeanne d'Arc	1901	11,329	20.0	2	14	23
Leon Gambetta	1903	12,550	20.0	4	16	24
Gloire	1903					
Marseillaise	1902	10,014	19.5	2	14	22
Condé	1903					
Amiral Aube	1903					
Gueydon	1902					
Montcalm	1901	9,517	19.0	2	12	22
Dupetit Thouars	1904					
Dupleix	1902					
Desaix	1903	7,710	18.6		12	14
Kléber	1903					
Dupuy de Lôme	1893	6,783	19.0	2	6	20
Pothuau	1896	5,460	17.0	2	10	18
Latouche Treville	1894					
Chanzy	1894	4,800	16.3	2	6	16
Amiral Charner	1894					
Bruix	1895					
Total	18	147,049	18.8	32	198	345

German Armored Cruisers	Year	Tonnage	Speed	Battery—Heavy	Mean	Light
Fürst Bismarck	1897	10,690	18.5	4	22	18
Prinz Heinrich	1900	8,931	20.5	2	20	14
Prinz Adalbert	1901	9,050	21.0	4	22	14
Friedrich Karl	1902					
Roon	1903	9,600	21.0	4	22	14
Yorck	1904					
Total	6	56,921	20.5	22	130	88

With regard to the armored cruisers, the speeds given in Table II to the French cruisers are the maximum in service during a run of twenty-four hours; the speeds accredited to the German cruisers are those obtained on trial trip, which ought to be reduced by about a knot and a half for the comparison. This gives France a slight superiority. The Russo-Japanese war has not shown the utility of these ships, which are too large for scouts,

and too weak in battery and protection to take a place in the line of battle. France possesses here a considerable superiority in number, eighteen against six. But if we compare the units, it is seen that with a displacement about equal Germany has armored cruisers faster and better armed.

Let us take as an example the French cruiser *Gloire* and the German cruiser *Roon*. Both are of the same date. The German cruiser has a displacement slightly less, but it has the same speed in service. The *Gloire* has only two heavy guns and fourteen of medium weight as against four heavy and twenty-two medium, and though the French ship has twenty-two rapid fire guns to offset fourteen, this difference, as we said above, is rather apparent than real. As a result of this comparison, it may be affirmed that the German armored cruisers would be much better able to figure as units in the line of battle than would the French.

Comparing the protected cruisers of the first class as between the two powers in Table III, we notice the homogeneity and the

TABLE III.

French First Class Protected Cruisers	Year	Tonnage	Speed	Battery—Heavy	Mean	Light
D'Entrecastcaux	1898	8,123	17.5	2	12	18
Tage	1888	7,589	18.0		16	22
Cecille	1889	5,978	17.0		18	20
Guichen	1899	8,282	21.0		8	15
Chateaurenault	1900	8,025	21.0		8	15
Jurien de la Gravière	1902	5,692	20.0		8	16
Total	6	43,689	19.2	2	70	106

German First Class Protected Cruisers	Year	Tonnage	Speed	Battery—Heavy	Mean	Light
Kaiserin Augusta....	1892	6,320	21.6		20	28
Victoria Luise..... *Hertha* ..... *Freya*	1897	5,660	19.2	2	8	14
Hansa	1898	5,900	19.5	2	8	14
Vineta	1897					
Total	6	35,100	19.7	10	60	98

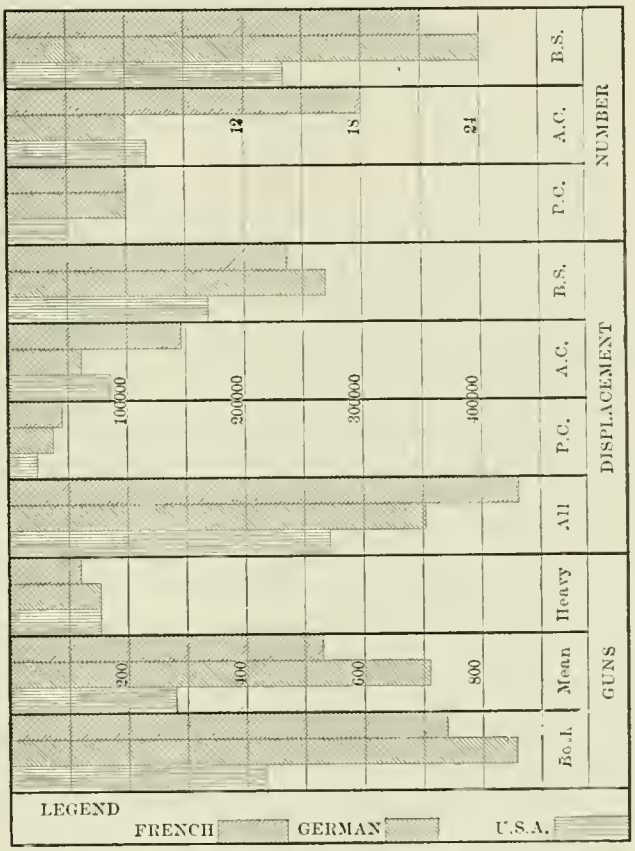
superior battery of the German ships. However, in the general total, these ships do not form a large factor of power. It was shown in the late war that when one of two fleets is defeated the cruisers may escape by virtue of their speed, but this does not prove that they possess any utility in the combat.

In the fleets of torpedo craft, France possesses an overwhelming superiority. This is shown by the fact that France has forty-three torpedo destroyers and nine torpedo cruisers against thirty-seven and ten respectively; forty high-sea torpedo boats, one hundred and eighty-two of the first class and twenty-seven for the colonies, a total of two hundred and forty-nine, against the German seventy-eight; and thirty-five submersibles and submarines as against several of the Holland type under construction for Germany.

The real value of this class of ship is problematical. It will suffice to say that in the late war in the Far East they have acted simply as accessories to the fleet. For a long time France has lived upon the belief that torpedo craft costing a million francs could blow up a battleship which cost forty millions; but facts do not seem to support this theory. However, the superiority of France is very evident, for her torpedo destroyers, high-sea torpedo boats and new submarines of large tonnage can very greatly assist the large units of power in their respective capacities.

The preceding comparison shows that France has an actual inferiority in large units. She has allowed herself to be overtaken and passed, and the question now is to regain the previous advantage. If we consider the French navy and the German navy as they will exist in 1908, we find that at that period France will have as a fleet of the first line seventeen battleships, fifteen armored cruisers of the first class and five of the second class. The second line will consist of eight battleships, nine coast defense ships, four armored cruisers of the second class and thirty-three protected cruisers.

The German act of June 14, 1900, provides for the German navy in 1908 in the first line twenty-seven battleships and eight first class armored cruisers. In the second line there will be eleven battleships, eight coast defense ships and forty-four protected cruisers. Again, it is necessary to note that the German ships will be in 1908 faster, better armed, and more homogeneous than the corresponding French ships. France cannot claim any advantage, the figures speak for themselves.



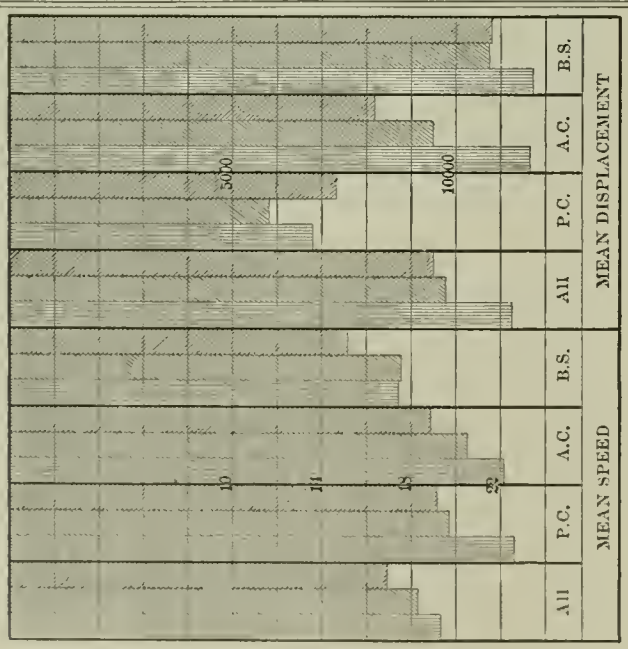
COMPARISON OF BATTLE FLEETS.

It is difficult to prophesy what the condition of affairs will be in 1919, which is the period when the navies of the two countries will be found definitely completed so far as the present programs of construction are concerned. Germany will possess in 1917, in accordance with the act above noticed, a very formidable array of ships, thoroughly modern, and consisting of thirty-eight battleships, fourteen armored cruisers and thirty-eight protected cruisers. If there is any change made in the German program care will certainly be taken to still further increase the power of the fleet to be provided. If France does not wish to be relegated from the point of view of naval power to the third rank, or perhaps even to the fourth or fifth, because the fleets of the United States and of Japan are increasing continuously, it is necessary for the country to make a great effort.

Editor's Note: In this connection, it will be of interest to see where the United States stands with regard to the two under comparison. With this idea in view Table IV has been compiled, showing the present strength of the American navy in the three classes of ships tabulated for the French and German navies. It will be seen at a glance that the battleship strength of the United States Navy as at present constituted falls very

TABLE IV.

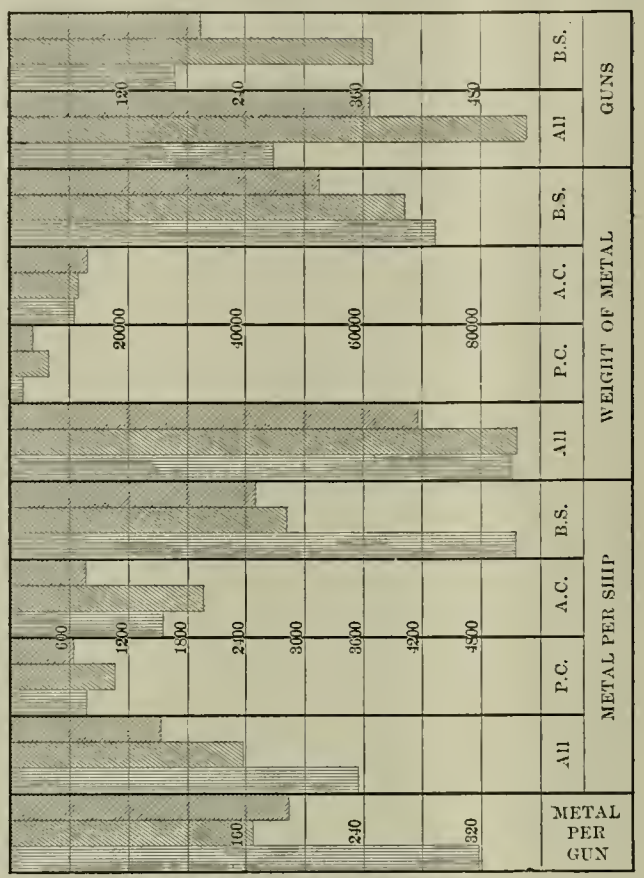
United States Battleships	Year	Tons	Speed	Battery—Heavy	Battery—Mean	Battery—Light
Indiana, *Massachusetts*, *Oregon*	1893	10,288	16.2	12	4	26
Iowa	1896	11,346	17.1	12	6	24
Kentucky, *Kearsarge*	1898	11,520	16.9	8	14	28
Alabama, *Illinois*, *Wisconsin*	1898	11,552	17.2	4	14	23
Maine, *Missouri*, *Ohio*	1901	12,500	18.0	4	16	20
Rhode Island, *Virginia*	1904	14,948	19.0	12	12	32
Total	14	167,302	17.5	112	160	348
Armored Cruisers						
New York	1891	8,150	21.0	6	12	10
Brooklyn	1895	9,215	21.9	8	12	16
Charleston	1904	9,700	22.0		14	42
Colorado, *Maryland*, *Pennsylvania*, *West Virginia*	1903	13,680	22.3	4	14	38
Total	7	81,785	22.1	30	94	220
Protected Cruisers						
Olympia	1892	5,865	21.7	4	10	18
Columbia, *Minneapolis*	1892, 1893	7,350	22.9	1	10	15
Total	3	20,565	22.6	6	30	48



CHARACTERISTICS OF THE AVERAGE SHIP.

far short of that of either of the two European powers, and although the amount of construction now on hand in American yards is greater than in either of the other cases, and, indeed, is about equal to the two combined, yet the slowness of our construction discounts in very large measure the gross quantity of tonnage uncompleted.

When it comes to the question of armored cruisers, the American forces seem to be much stronger than the German, but



GUNFIRE OF THE SEVERAL CLASSES OF SHIPS.

very markedly weaker than the French; although our units are larger and faster than is the case with either the French or the German, and better armed than the French. In first class protected cruisers we are in a decided minority, having only three against six for each of the other navies.

Another table gives the whole situation in a nutshell as regards

TABLE V.

		Ships	Tons	Guns	Average Tons	Average Sp'd	Average G'ns	Broadside G'ns	Broadside Metal	Broadside Mean Per ship	Broadside Mean Per gun
France.	Battleships.	21	236,709	340	10,796	15.2	16.2	194	52,024	2,477	268
	Armored Cruisers.	18	147,049	230	8,169	18.8	12.8	131	13,366	743	102
	Protected Cruisers.	6	43,689	72	7,282	19.2	12.	40	3,786	631	95
	Total ...	45	427,447	642	9,499	16.9	14.3	365	69,176	1,537	189
Germany.	Battleships.	24	258,911	636	10,788	17.6	26.5	369	67,783	2,814	184
	Armored Cruisers.	6	56,921	152	9,487	20.5	25.3	87	11,770	1,962	133
	Protected Cruisers.	6	35,100	70	5,850	19.7	11.7	67	6,467	1,078	97
	Total ...	36	350,932	858	9,748	18.3	23.8	523	86,020	2,389	164
United States.	Battleships.	14	167,302	272	11,750	17.5	19.4	172	71,836	5,131	418
	Armored Cruisers.	7	81,785	124	11,684	22.1	17.7	75	10,902	1,557	145
	Protected Cruisers.	3	20,565	36	6,855	22.6	12.	21	2,256	752	107
	Total ...	24	269,652	432	11,236	19.3	18.	268	84,994	3,541	317

number of ships, total and average displacement, average speed and total and average number of guns, included under the headings of "heavy and mean." Under the heading "Broadside" are given figures covering the weight of metal which could be discharged in one round of the guns bearing on one side of the ship. The mean weight of these projectiles is also given. No gun smaller than the German 3.4-inch is included. The superiority of the American battleship is very marked. This table covers the three classes of ships for the three navies under consideration, and is supplemented by diagrams which give a graphic representation of the situation.

La Provence has six steel decks, named from the bottom: fourth, third, saloon, upper, promenade and upper promenade decks. The upper promenade deck aft contains the cafe and terrace cafe, with a seating capacity of 60 persons, decorated in pale green, style Directoire; while forward on this deck the chart house, captain's and officers' cabins and wireless cabin are located, 49 feet above the water line.

On the promenade deck are located two large suites of rooms, consisting of parlor, sleeping room and private bath, sumptously decorated in the style of Louis XVI; and connected with these suites are large family cabins capable of accommodating three

LA PROVENCE AT FULL SPEED ON TRIAL TRIP OFF BELLE ILE.

THE NEW FRENCH LINER LA PROVENCE.

This ship, which was partially described in our issue for August last, and the launching of which was illustrated in our issue for May, 1905, reached New York on her maiden voyage April 27. The principal dimensions, as given in August, show a length over all of 627 feet, a beam of 65 feet, a depth of 42 feet and a draft of 26 feet 9 inches. The corresponding displacement is 19,160 tons. The gross tonnage of the ship is 14,744; the under deck tonnage, 10,553; the net tonnage, 3,833.

Propulsion is by twin screws operated by triple expansion four cylinder engines of an aggregate of 30,000 horsepower, the trial speed having been somewhat less than twenty-three knots. Steam is supplied by twenty-one cylindrical boilers working at a pressure of 206 pounds per square inch, and fitted with the Howden system of forced draft. The coal consumption per day is given as 450 tons, while the bunkers have a total capacity for 4,400 tons.

The cylinder diameters are respectively 120, 194 and two of 242 centimeters, with a stroke of 170 centimeters. These figures correspond respectively to cylinder diameters of 47¼, 76½ and 95¾ inches, the stroke being 67 inches. The boilers have mean diameters of 17 feet 1 inch and 16 feet 1 inch in the two sizes, with a length of 10 feet 10 inches in each case. The aggregate grate surface is 1,570 square feet with heating surface 58,172 square feet, the ratio of the one to the other being 37 to 1.

On trial trip the speed reached was 22.7 knots, with an average of 22.3, at a draft of 26 feet 11 inches. The average coal consumption per indicated horsepower per hour figured out at about 600 grams, which is 1.32 pounds, a remarkably good performance. The maximum power developed was 30,625 indicated horsepower. The revolutions were 87 per minute.

STARBOARD BOW, BATTLESHIP LIBERTE IN DISTANCE.

people if desired. In addition to this there are four immense cabins de luxe consisting of sitting room, parlor, bathroom and toilet, and all the suites are distinctive in decoration. No first-class room has more than three berths, while in many cases the lower berths are arranged as luxurious settees.

On this deck are also six single cabins de luxe without bath, nine large cabins de famille, together with eight large outside rooms and eight comfortable inside cabins. Here are also located the library and music room. All these apartments are heated by steam, lighted by electricity and provided with telephones, and in addition the suites, luxes, dining saloon, ladies' room and smoking room are supplied with electric fans and radiators.

Besides the portholes, numerous ventilators from deck, etc., a special system of piping along the ceilings of the cabins has been installed, thus insuring complete and perfect ventilation, which can be regulated at will

The social hall of the first class is a splendid apartment, the walls being decorated in white with gold carvings, and the furnishings of the Louis XVI period. In place of the usual circular port holes are fitted large square windows, while a skylight in an artistic glass dome furnishes light throughout the day. At night illumination is furnished by electricity in luminous ceiling domes.

VIEW OF THE AWNING DECK, TAKEN FROM NAVIGATING BRIDGE.

TELEGRAPHS, STONE-LLOYD AND RUDDER INDICATORS, ON NAVIGATING BRIDGE.

On the upper deck will be found the first-class smoking room finished in dark oak, luxuriously upholstered and decorated, style Renaissance, capable of seating comfortably at tables conveniently arranged 76 persons at a time.

The entrance of the main stairway leading from the promenade to the upper deck is finished in teak wood, elaborately carved; the skylight or dome is supported by an allegorical figure representing "La Provence," offering to the world the olive branch of peace, surrounded by young Tritons with garlands of fruits, flowers and shells, while beneath this allegorical figure is a large plate glass mirror, on each side of which are paintings after the style of the masters of the eighteenth century, and suspended over the paintings are lights in the shape of lanterns, after the Versailles style.

From the main entrance on the upper deck we enter the spacious first-class dining saloon, 65 feet in length and 45 feet in width, located amidships, between the two funnels, with a seating capacity of 250 passengers at a time. This is practically a reproduction of the dining room in the Duke of Subise palace in Paris, decorated in light green, the fireplace surmounted by the figure Amphitrite, the goddess of the sea, seated on a float filled with flowers. There are twenty-six dining tables, with ample chair space, bronze candelabra of the style of Louis XV, vases filled with natural flowers, and everything arranged with an eye to real comfort.

On the saloon deck are fifty-six large outside cabins, steam heated, lighted by electricity, provided with telephones, and every comfort and convenience that can be devised for the regular traveler. In addition to this there are seventy-two comfortable, well-ventilated inside cabins. On this deck we have the office of the chief steward; the ladies' boudoir, decorated in light blue and gold style of Louis XVI; the children's dining saloon, and the hair

dressing parlor. A manicurist, also a stenographer, will be at the disposition of those passengers requiring such service during the voyage. A regular daily newspaper will be published on board, containing all wireless news received from shore, entertainment notices, etc.

LA PROVENCE UNDERGOING COMPLETION IN BUILDER'S YARD.

Another unique feature in the ship is the installation of an elevator running from the saloon deck to the upper promenade deck, operated by electricity and located on the starboard side of the main entrance.

The second-class accommodations, providing for 204 persons, and consisting of twenty-seven outside and thirty inside rooms, some with two and some with four berths, are located on the after portion of the main deck; with the dining room on after portion of upper deck, and smoking room and ladies parlor on after portion of promenade deck.

Roomy quarters have been provided for the accommodation of 1,000 third-class passengers, with special compartments for families and single ladies, and a special shower bathroom installed for their use.

The safety of the ship is assured by means of an elaborate outfit of watertight doors on the Stone-Lloyd system. Steering is by the Brown hydraulic steering gear with electric control. Twenty steel lifeboats and six life rafts are installed, any of which can be lowered by the quadrant davit system in forty seconds, there being four men employed for each boat.

The double bottom is divided into ten watertight compartments, capable of holding a total of 1,770 tons of water ballast. The hull proper is divided into twenty separate watertight compartments by means of nineteen watertight bulkheads.

The maiden voyage from Havre occupied 6 days 9 hours and 10 minutes, which is a new record for the distance between these ports, the previous record of 6 days 9 hours and 20 minutes having been made last year by *La Lorraine*. The mean speed for the 3,201 nautical miles figures out at 20.9 knots, which will, of course, be much better when the engines get shaken down into smoother running order. As it was, however, they ran very smoothly, passengers reporting that there was almost no vibration from either engines or propellers, even during the heavy weather of the third day. The daily runs are given as 593, 537, 484, 508, 519 and 560 nautical miles. The daily speeds figure out respectively at 21.4, 21.65, 19.5, 20.5, 20.9 and 21.5 knots. On the return voyage the time was 6 days, 7 hours, thus lowering the previous record of 6 days, 8 hours, 45 minutes, held by *La Savoie*. This is a creditable performance for a new steamer, and is one to which the builders and company can look with much satisfaction.

The crew consists of a total of 435, there being 10 officers and 46 sailors in the deck department; 15 officers and 251 men in the engineering department, and 113 in the stewards' department.

AWNING DECK, SHOWING "QUADRANT" DAVITS.

The keel of the ship was laid December 1, 1903; she was launched March 21, 1905; had her trial trip March 13, 1906, and sailed on her maiden voyage April 21, 1906.

LENGTHENING OF THE STEAMER HAMILTON.

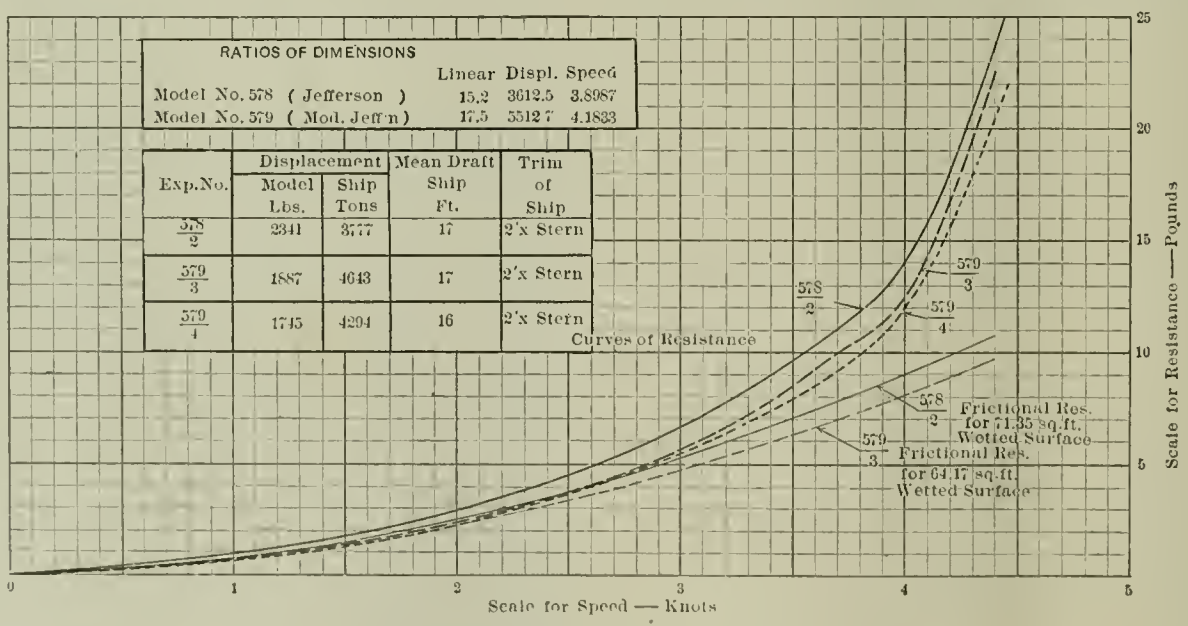
BY ALEXANDER WILLS.

The history of the Old Dominion Steamship Company, which is one of the most prominent lines on the Atlantic Coast, and provides a daily passenger and freight service between New York and the Virginian ports of Norfolk and Newport News, is an index of the growth of the shipping between these ports. The management of the above company is alive to all interests of its patrons, this fact being demonstrated by the service afforded, the vessels of their main line being in speed, passenger accommodations, etc., the equals of any engaged in the coastwise trade, as well as being equipped for the carrying of the large amount of freight handled between the two ports.

The present main line fleet consists of the steamers *Monroe*, *Hamilton*, *Jefferson*, *Princess Anne* and *Jamestown*, all of which have a speed of from 15 to 15½ knots. Of the above, the *Monroe* is the largest and latest, and was fully described in our August, 1903, number. The *Hamilton* and *Jefferson* are sister ships, the *Princess Anne* is the same size as these two vessels, and the *Jamestown* is somewhat smaller, being the reserve boat of the fleet.

THE STEAMER HAMILTON BEFORE BEING LENGTHENED.

To meet the large increase in the amount of freight to be handled, the company has recently had the *Hamilton* lengthened, this means of caring for the increased traffic having been adopted in order to give an increased daily movement, freedom from congestion at terminals, and to avoid interference with the sailing schedule, which would result if the additional freight capacity had been provided in another vessel.


RATIOS OF DIMENSIONS
Linear Displ. Speed
Model No. 578 (Jefferson) 15.2 3612.5 3.8987
Model No. 579 (Mod. Jeff'n) 17.5 5512.7 4.1833
Exp.No. | Displacement Model Lbs. | Displacement Ship Tons | Mean Draft Ship Ft. | Trim of Ship
578/2 | 2341 | 3777 | 17 | 2'x Stern
579/3 | 1887 | 4643 | 17 | 2'x Stern
579/4 | 1745 | 4294 | 16 | 2'x Stern
Curves of Resistance
578/2
579/3
579/4
Frictional Res. for 71.35 sq.ft. Wetted Surface
Frictional Res. for 64.17 sq.ft. Wetted Surface
Scale for Resistance — Pounds
Scale for Speed — Knots
0
1
2
3
4
5
10
15
20
25

CURVES OF RESISTANCE OF JEFFERSON MODEL, BEFORE AND AFTER LENGTHENING.

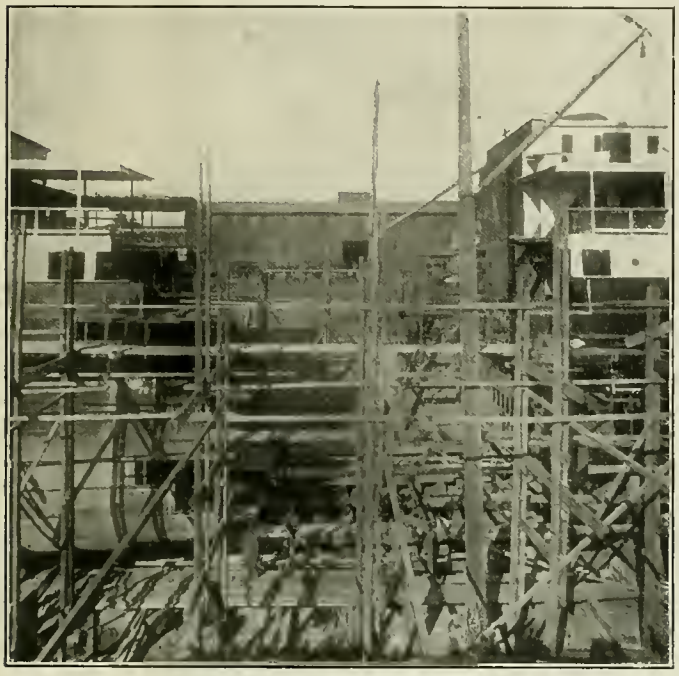
The present main line fleet consists of the steamers *Monroe*, *Hamilton*, *Jefferson*, *Princess Anne* and *Jamestown*, all of which have a speed of from 15 to 15½ knots. Of the above, the *Monroe* is the largest and latest, and was fully described in our August, 1903, number. The *Hamilton* and *Jefferson* are sister ships, the *Princess Anne* is the same size as these two vessels, and the *Jamestown* is somewhat smaller, being the reserve boat of the fleet.

To meet the large increase in the amount of freight to be handled, the company has recently had the *Hamilton* lengthened, this means of caring for the increased traffic having been adopted in order to give an increased daily movement, freedom from congestion at terminals, and to avoid interference with the sailing schedule, which would result if the additional freight capacity had been provided in another vessel.

The *Hamilton* is a single screw steel steamer of the hurricane

deck type, built by the Delaware River Iron Shipbuilding Company (Roach's yard), at Chester in 1899, and before lengthening was of the following dimensions:

Length aft side of stem to fore side of stern post	304 feet.		
Beam molded	42 feet	Gross Tonnage	3129
Depth to Main Deck	27 "	Net "	2026



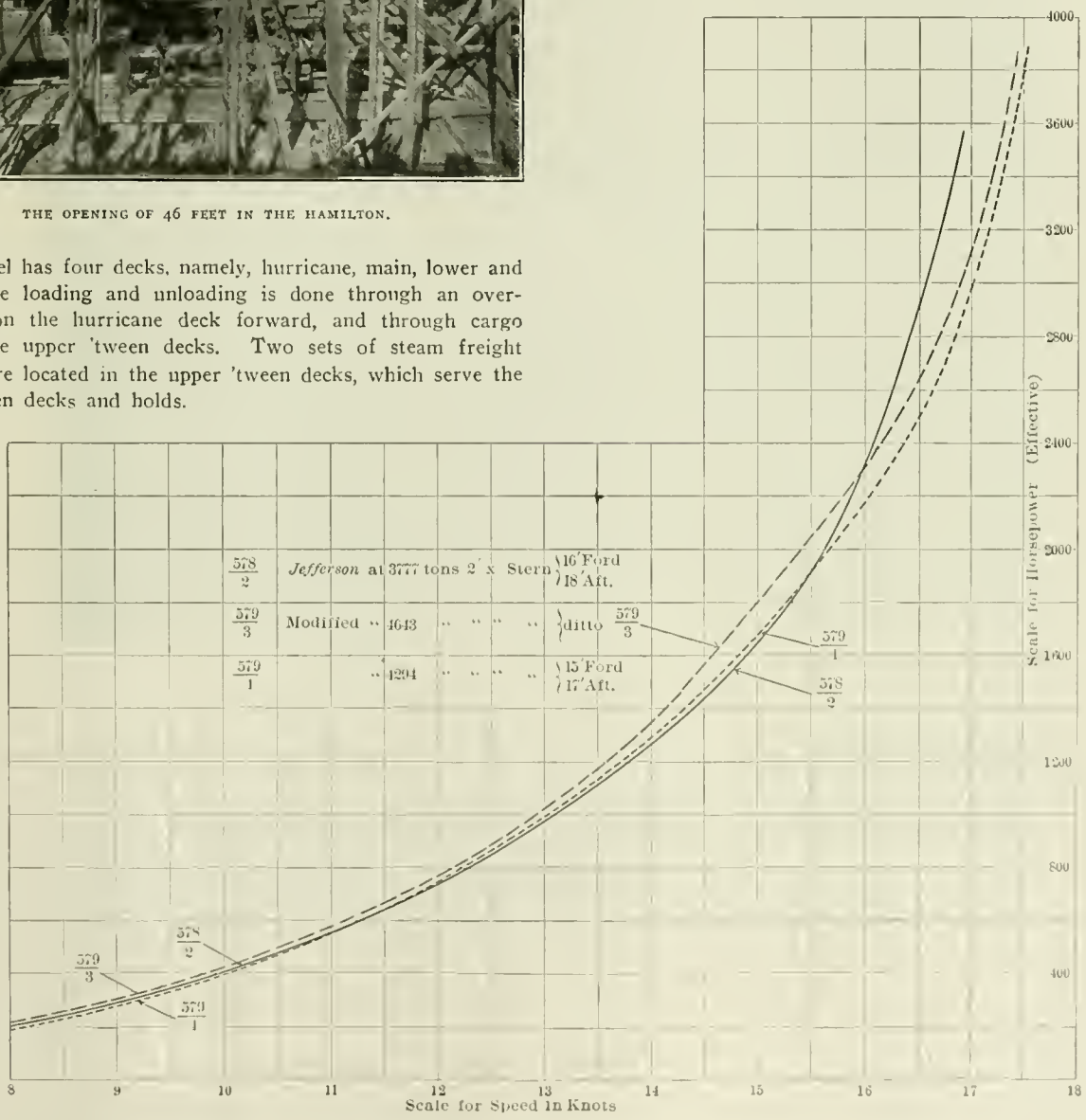
THE OPENING OF 46 FEET IN THE HAMILTON.

The vessel has four decks, namely, hurricane, main, lower and orlop. The loading and unloading is done through an over-all hatch on the hurricane deck forward, and through cargo ports in the upper 'tween decks. Two sets of steam freight elevators are located in the upper 'tween decks, which serve the lower 'tween decks and holds.

Accommodations for first-class passengers are provided on the main deck aft of the machinery casings, and in a deck house on the hurricane deck extending from the over-all hatch to within about 30 feet of the stern. The pilot house, officers' quarters, and first-class smoking room are located on the shade deck, which extends from the over-all hatch aft.

The first-class dining saloon is located on the main deck directly aft of the engine casing, with the main stairway at its after end leading to the social hall on the hurricane deck. The galley is on the main deck between the boiler and engine casing, and the pantry is abreast of the engine casing on the port side. The officers' mess room is on the hurricane deck over the galley. Quarters for the crew and accommodations for steerage passengers are on the main deck forward.

The machinery consists of a triple expansion engine with cylinders 27, 44½ and 73 inches in diameter by 54 inches stroke, and four Scotch boilers 14 feet 3 inches diameter by 12 feet 7 inches long. All cylinders are fitted with piston valves worked by Marshall valve gear. The boilers were built for a working steam pressure of 190 pounds, and have each three furnaces of 46 inches inside diameter, the total grate surface being 293 square feet and the heating surface 9,905 square feet (ratio 33.8 to 1). The condenser forms part of the engine framing,



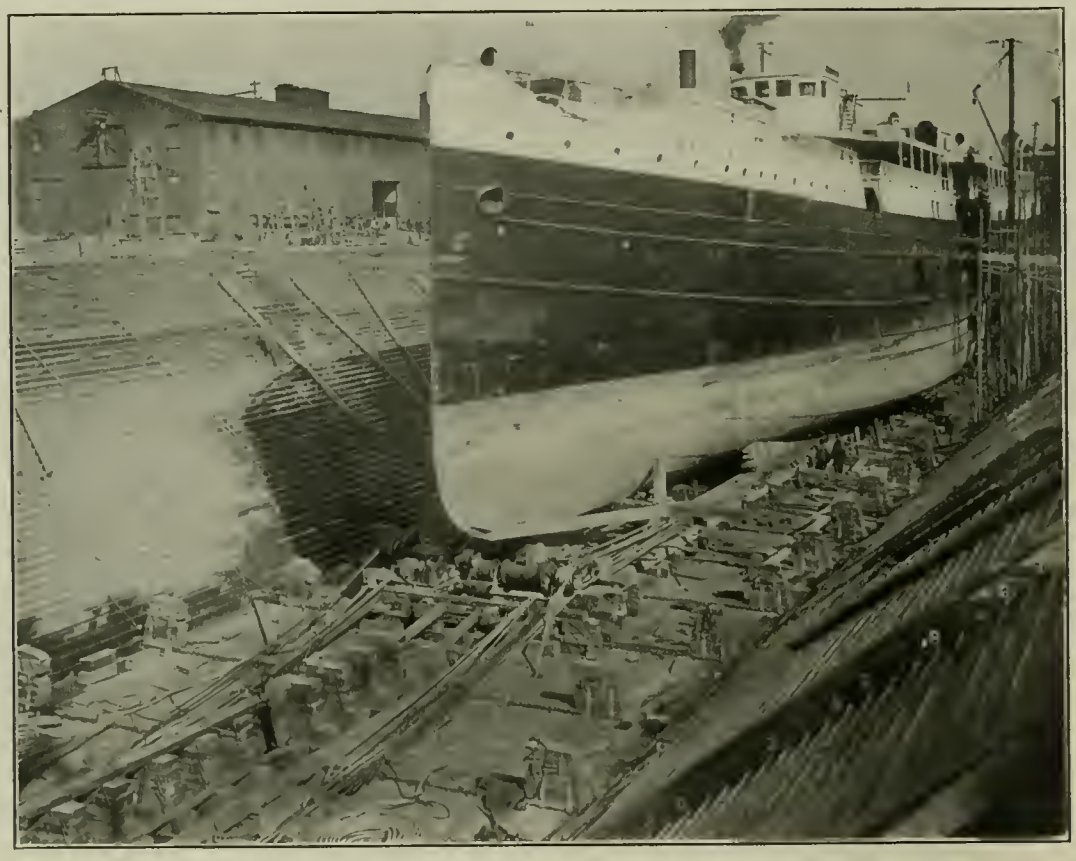
POWER-SPEED CURVES FOR ORIGINAL SHIP AND LENGTHENED SHIP.

and has 6,100 square feet of cooling surface. The air pump is worked from the main engine. Under average conditions the main engine gives about 3,000 indicated horsepower.

After the decision to lengthen the vessel had been reached, the amount to be added was one of the first things to be considered. Within certain limits this length had to be governed by the length of piers at the terminals, and the location of the cargo ports, relative to the pier gangways. These conditions decided the owners to adopt an added length of 46 feet. This question having been settled, the effect of the increase in dimensions on the power and speed of the vessel was investigated. Models of the original and lengthened vessel were towed in the United States experimental model basin in Washington, at different drafts and speeds, to determine the effective horsepower required. The results of the experiments are indicated on the accompanying curves. These curves show that for speeds under 16 knots at the mean draft of 17 feet, somewhat more power was required to drive the lengthened vessel, but that for speeds beyond 16 knots, the lengthened vessel required less power than the original. For the same draft there is a difference of 866 tons in displacement, so that while the effective horsepower per ton of displacement at 15 knots was 0.436 for the original vessel, it was only 0.3875 for the lengthened vessel, a decrease of over 11 percent.

With the original vessel at 17 feet mean draft and the lengthened vessel at 16 feet mean draft, the curves of effective horsepower follow each other very closely and cross at 15.1 knots. With these drafts, the difference in displacement is 517 tons in favor of the lengthened vessel, and the effective horsepower required per ton of displacement at 15½ knots is 12.1 percent less. The increase in power required to drive the lengthened vessel over that required for the original at the same draft as shown by the model experiment was not considered enough to warrant any increase in the size of machinery, and no changes were made.

The contract for lengthening the *Hamilton* was awarded to the Newport News Shipbuilding and Dry Dock Company, and the vessel arrived at the builders' yard on January 13, 1906. The most desirable point to cut the vessel had been previously determined to be at the after boiler room bulkhead, and as the location of the machinery relative to its distance from the stern was not to be altered, it was necessary to remove the boilers from the ship. The vessel was put under the sheer legs, the piping in boiler room disconnected, and the boilers, uptakes and stack removed from the ship, also the boiler casing and other interior work involved in the alterations. A set of sliding and ground ways had, in the meantime, been placed in the dock, and on January 26 the vessel was floated into dry dock, stern first, to the desired position over the ways, and the dock emptied. The work of cutting and the preparations for pulling the sections apart were carried on simultaneously and on February 3, everything having been prepared, the sections were pulled part successfully in sixteen minutes after power was applied.



ARRANGEMENT OF TACKLE TO SEPARATE ENDS OF VESSEL.

The apparatus adopted to pull the sections apart is shown on the accompanying photographs. The ground and sliding ways were placed in position with a declivity of 6 inches in 200 feet, the ground ways used being the regular launching ways, with dimensions of 30 by 15 inches. They were supported about 21 inches from the bottom of the dock, and were about 19 feet apart on the outboard sides. The sliding ways were 26 by 14 inches, and at their outer ends were fastened together, and shores placed between the cross ties and clips bolted on the shell From the cross tie a shore was fitted on each side to clips bolted on the stem, the object of these shores being to prevent movement of the sliding ways without a corresponding movement of the vessel. To support the end of the vessel under the forefoot a 14-inch sliding way was used under the keel.

The tackle used in pulling consisted of two sets of four-fold 7-inch manila purchase on each side, fastened to the ends of the

sliding ways and to the bottom of the dock. Two 35-horse-power electric winches were fastened to the ground ways to supply the necessary power, and two 100-ton hydraulic jacks were provided to help the start. The pull was directly on the sliding ways, and after power was applied, the sections separated readily, the forward end being pulled away evenly without a hitch, to the stop provided on the ways.

THE LENGTHENED HAMILTON BEING FLOATED OUT OF DRY DOCK.

The new material used in the lengthening of the *Hamilton* was handled by derricks set in the dock on each side of the vessel, as shown on accompanying cuts. The new frames, floor plates, etc., had been furnaced previous to the cutting of the vessel, and by the time the sections were pulled part they were all ready to put in place. On March 12 all external steel work was completed, and the vessel was floated out of the dock and put under the sheer legs to have her boilers and mast re-installed, the latter having been removed to be shortened. On April 14 all work had been completed, and the vessel left the ship yard to resume her regular run.

The alterations in the *Hamilton* were carried out under the survey of the American Bureau of Shipping, and the United States Standard, and the vessel now is as strong as originally. The new framing is of a somewhat greater section than the old, the new floor plates are parallel to the base line, thus making them deeper at the bilge than the old ones, and new belt frames and an additional watertight bulkhead were added. The main deck sheer strake was doubled for a length of 188 feet

THE HAMILTON, AS LENGTHENED AND RECONSTRUCTED.

with 25-pound plates, and 22½-pound plate doubling was added to the bilge strake for a length of 204 feet.

In order to provide additional cargo handling facilities for the increased 31 percent in the cargo space, an additional cargo port was fitted on each side forward of the boiler casing, between the lower and main decks, and an additional pair of cargo gangways was fitted between the main and hurricane decks. The space formerly occupied by the boilers is now used for freight, and two hatches side by side were provided in the main, lower and orlop decks, and independent freight elevators fitted in them. The engines for these elevators are placed on the lower deck, the elevators in general being similar to those on the steamer *Monroe*. At these new hatches on the main deck a hoisting engine and two cargo cranes were fitted.

Extensive additions were also made to the passenger accommodations. In the additional length provided on the hurricane deck new staterooms were fitted, and new stairways added for access from the hurricane deck to the main deck and to the first-class smoking room on the shade deck. The old smoking room located aft of the boiler casing on the shade deck was divided and made into a dining saloon and smoking room for intermediate passengers. On the shade deck forward of the boiler casing a new and larger first-class smoking room was built and fitted with toilet and buffet. No changes were made in the passenger accommodations on the main deck, but the galley and pantry were considerably increased. The passage at the side of the pantry was dispensed with, and the pantry extended to the ship's side. The galley was also widened about 8 feet, all dressers and wood work renewed, dumb waiter increased and new galley floor fitted. Other changes on the main deck consisted in fitting a baggage room abreast of the boiler casing, and changing the location of the baggage ports. The dynamo room abreast of the engine casing was increased in size, and the electric plant increased from one 20-kw and one 4-kw generating sets to one 25-kw and one 20-kw sets, thus materially increasing the lighting capacity.

While the above alterations were being made to the hull, extensive repairs were also made to the machinery. The main engine was completely overhauled and a new high pressure valve stem fitted, the top section of condenser re-tubed, and a new tail shaft fitted. A Reilly feed-water heater was also fitted in the engine room.

The four main boilers were entirely overhauled and new middle furnaces fitted in each one. An entire new smokestack was fitted. Two 54-inch Sturtevant fans were placed in the upper part of the fidley, with suctions from the top of the fidley and from the cargo space between decks. These fans serve to cause a circulation of air in 'tween decks, and also to ventilate the fire-room, as well as to assist the draught.

In addition to all the repairs and alterations, the vessel was thoroughly cleaned and re-painted throughout, so that now she is practically a new ship.

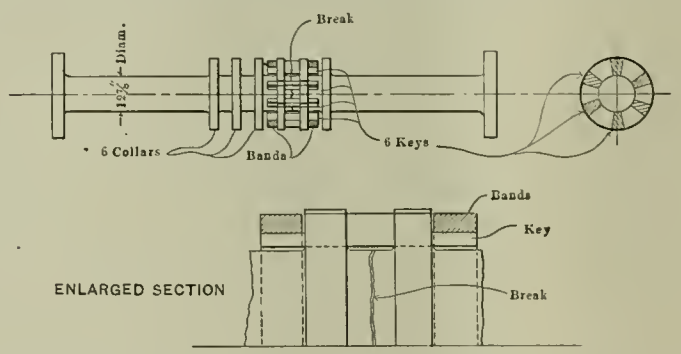
The following table gives some interesting figures relative to the percentage of increased cargo capacity and passenger accommodations obtained by the lengthening of the vessel:

	Original	Lengthened	Percent Increase
Freight space (in terms of cubic feet)	163,400	213,400	31
Freight ports	6	10	67
" hatches	5	6	20
" ports and hatches square feet	793	1,174	48
Cubic feet of freight per square foot hatches and ports	206	182 (—)	12
Freight hoisters	4	6	50
" elevators	4	6	50
First-class state rooms	53	62	17
First-class W. C's. for men	5	6	20
" " W. C's. for women	4	6	50
" " smoking room square feet	241	510	112
First-class galley square feet	198	290	47
" " pantry " "	180	300	67
Passenger exit forward	—	1	—
Intermediate staterooms	5	6	20
" dining saloon square feet	—	165	—
Intermediate smoking room square feet	—	88	—

Repair of a Thrust Shaft at Sea.

On February 21, in latitude 32° 27′ north, longitude 38° 44′ west, during a heavy gale and head sea, the Spanish single screw steamship *Ida* of Bilboa, Captain Arano, en route from Liverpool for Cuba with cargo and passengers, sustained a breakage of the thrust shaft between the second and third collars, the after portion being drawn away from the forward end 1⅛ inches. It was found that the after horseshoe collar had also broken, and of course the ship was entirely unable to proceed without some sort of repairs. During the three days in which she was laid to, the engine room staff effected temporary repairs in order to enable the ship to cover the distance of 1,240 miles to Bermuda, which place was reached March 10.

The method of making these repairs was very ingenious. It consisted in cutting six slots in two collars, one each side of the break, the slots being spaced sixty degrees around the circumference, and measuring 1½ inches wide and 2¼ inches deep.



They were then filled with keys forged and fitted to place, the keys being held in place by two bands or rings around the shaft measuring 2½ inches wide and ¾ inch thick. In addition to this, two holes were drilled diametrically across the shaft at the break, and pins were driven in in order to ease the shearing stress upon the keys. These repairs permitted the ship to make slow speed ahead, but she could not steam astern because, on account of the displacement of the shaft axially, no horseshoe collar could be fitted aft of the break, and hence no thrust could be permitted on the forward side of the propeller, as this would have resulted in pulling the sections of the shaft entirely apart.

Great credit is due the engineering staff of the ship for the way in which repairs were made, the more so on account of the difficulties which they had to encounter. They had no proper material from which to make keys, and had to use tube stopper rods, which they proceeded to cut up and weld together to obtain the requisite dimensions for the keys.

The *Ida* was built by J. Laing of Sunderland, England, in 1890, to the order of the Linea de Vapores Serra, and measures 1,805 tons net and 3,091 tons gross. She is constructed of steel and measures 340 feet in length, with a beam of 41 feet 1 inch and depth of 26 feet 3 inches. There is a bridge house 78 feet in length and a forecastle with a length of 34 feet. The triple expansion engine has cylinders 24½, 40 and 66 inches in diameter, with a stroke of 45 inches.

W. B. Smith.

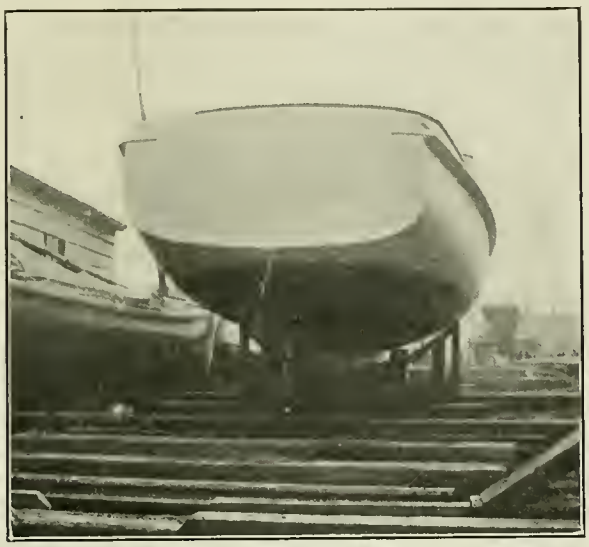
A FORTY-FOOT CRUISING LAUNCH.

BY JOHN Q. WALTON.

A forty-foot cruising launch has just been completed and launched from the shop of Captain Reagan, at Washington, D. C. The general dimensions are as follows: Length, 40 feet; beam, 10 feet 6 inches; freeboard at bow, 53 inches; freeboard at stern, 34 inches; draft at wheel, 3 feet 1 inch; headroom in cabin, 6 feet 1½ inches, from top of floor to under side of carline.

The berths or locker tops are of extra width and very comfortable, being covered with double thick cushions. The space under the cushions is fitted with drawers, so that it is very convenient in getting anything out of the lockers. The cabin trunk and inside finish are of cypress, the outside and the cockpit of white pine, and the cockpit rail, or capping, of black walnut, bright.

The cockpit is large and exceptionally roomy; it is fitted with two seat lockers, one on each side, and two doors in after end to permit getting at the space under after deck. The cockpit deck is of cedar, 1⅜ inches thick, finished bright, is watertight and self-bailing. There is ample room for a few camp chairs, making it a very comfortable place in good weather, as it is cov-



STERN VIEW OF BELLROSE.

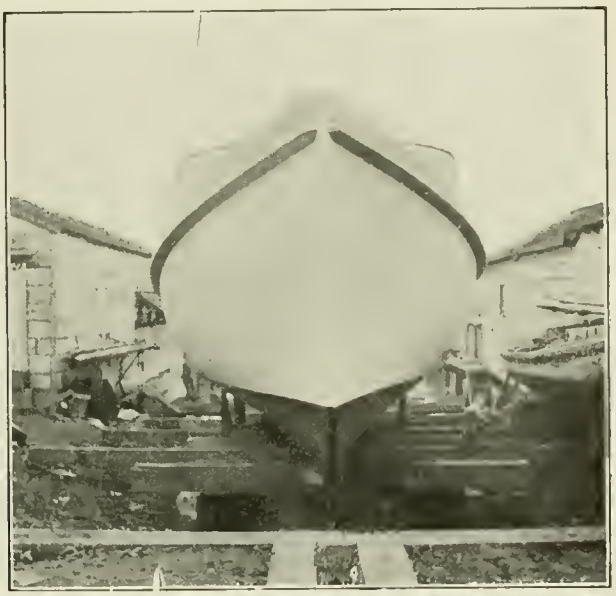
ered with a standing awning, extending over the companionway slide on house. The main deck is of cedar, 1⅜ inches thick, calked and painted; the plank sheer, sheer strake, clamps and bilge stringers are of yellow pine, each in one length, 1⅜ inches thick. The slides, companionway and companionway doors, are of selected white oak, and finished bright, the doors being paneled. The cabin roof is covered with No. 10 duck and thoroughly painted.

The planking is of white cedar, 1⅜ inches thick; the keel, stem, sternpost, deadwood, frames and floors are of selected white oak, the keel is 3½ inches sided, the stem 4½ inches sided, the deadwood 3½ inches sided, the shaft log and stern post 5 inches sided, and worked to shape. The frames are steam bent, 1½ inches sided, molded at keel 2½ inches, and 1½ inches at head. The floors are of white oak, well fastened to frames and keel. The deck frame is of yellow pine, as shown in illustration.

At the forward corners of house are fitted hackmatack knees 3 feet long on clamp and 2 feet long on beam, by 4 inches sided cut out in the throat to the curve of the house and thoroughly secured to clamps and beam; at the after end of cabin there are two hackmatack knees, extending 3 feet on beam and up on frame to the clamps; they are thoroughly secured to beam (cockpit beam) and frame; these knees are 2 inches sided.

At the forward end of cabin is fitted a bulkhead having a door in center. The space between this bulkhead and forward end of house is divided into galley and pantry, the galley being on the starboard side and the pantry on the port side. The pantry is fitted with dish racks, provision locker, and sideboard; a locker is located in the lower part of galley, for cooking utensils. Just forward of this space in the fore peak is located the ice box, which holds 200 pounds of ice; forward of ice box is the chain locker. Above the ice box, against the side of boat and under the deck beams, are secured two galvanized iron tanks for holding fresh water. They are filled through the hatch in forward deck, pipes being arranged for this purpose. These tanks are piped to the galley and pantry, and to the wash basin in toilet room aft.

The cabin table is formed by two turned stanchions fitted from floor to carlines at top of house, and a capping secured to these, the table leaves being hinged to this capping; the capping is 5½ inches wide, so that very little room is taken up when the leaves are dropped. In the after end of cabin, starboard side, is fitted a clothes locker with sliding door. As this space is out of the way and could not be economically used in cabin, it was



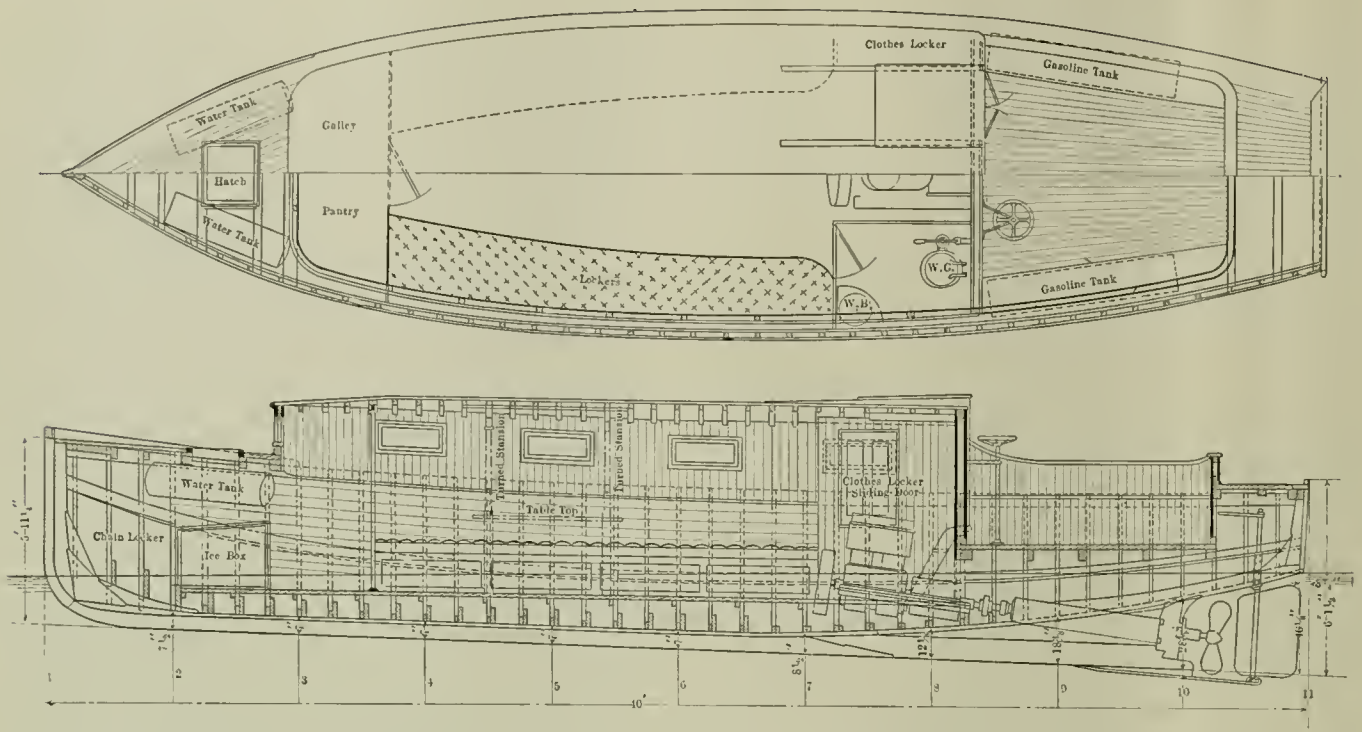
BOW VIEW OF NEW CRUISING LAUNCH.

formed into a locker, and is very roomy and conveniently located, and not in the way of anything.

On the port side of cabin, aft, is located the toilet room, fitted with a pump closet and stationary wash basin with running water. The fore and aft bulkhead has a portable shutter fitted in the lower part, so that it can be removed, if necessary, in overhauling engine. The engine foundation is made of white oak, the athwartship and fore and aft pieces being mortised and bolted together and thoroughly secured to boat.

Under the after end of cockpit floor is located a galvanized iron tank, placed athwartship; this tank is used for storing air for blowing the whistle; it is connected by piping to the air pump on engine, and to whistle on after end of house.

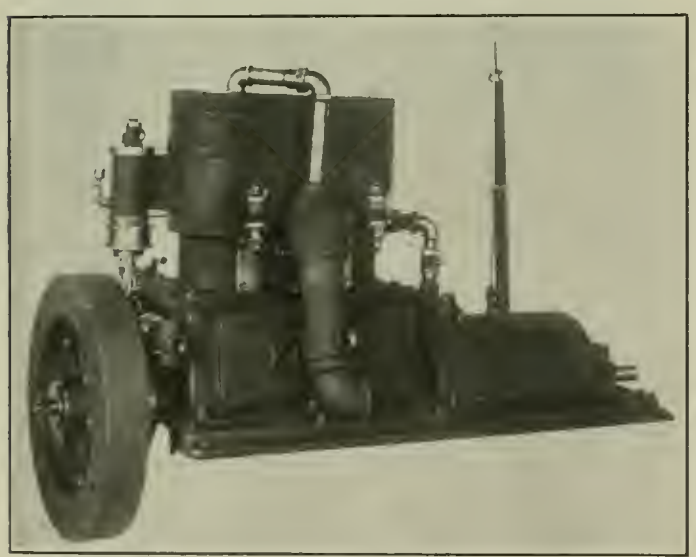
The boat is lighted by electricity from storage batteries, four batteries being placed under the cockpit deck and connected to the dynamo on the port side of engine just aft of flywheel. The dynamo is driven by belt from the engine, and the batteries are charged while the engine is running, so that they are always ready when wanted, whether the engine is running or not. There are five lights in the cabin, two on each side and one in the center between carlines, placed in a ceiling fixture. There is one light in toilet room, two lights in galley and pantry, one light in fore peak over ice box, and one portable for working



ACCOMMODATION PLAN AND INBOARD PROFILE OF 40-FOOT LAUNCH.

around engine. These batteries are also connected to the spark plugs of engine for ignition purposes.

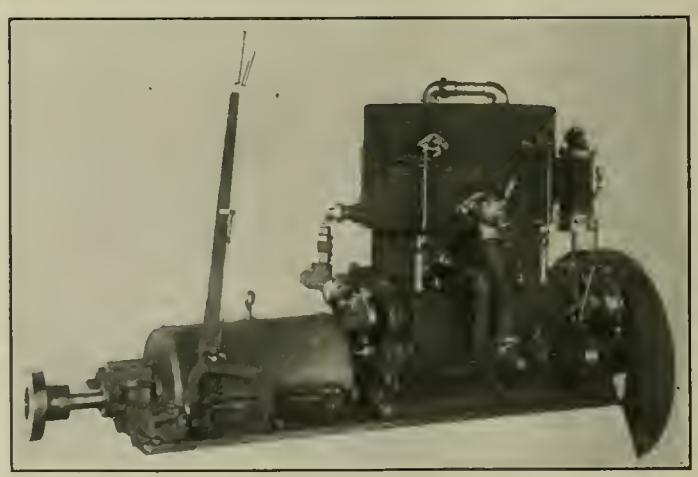
The gasoline tanks are located under seat lockers in cockpit. They are ceiled up so that no water can get into this space from cockpit. There are two tanks of copper, one on each side, connected by piping to each other and to the carburetor, and provided with valves, filling and vent pipes. In this way the gasoline is stored outside of the cabin or boat proper.



VIEW OF ENGINE FROM PORT SIDE.

The steering gear is of the automobile type, having a worm and quadrant with lever and chain to equalizing arm on tiller. The steering wheel shaft is vertical, and on port side in cockpit, as shown. A windlass is fitted on the forward deck; bow and anchor chocks are also fitted to this deck. Two anchors, one weighing 60 pounds and one 125 pounds with ⅜-inch chain, are carried. The running lights are oil burners.

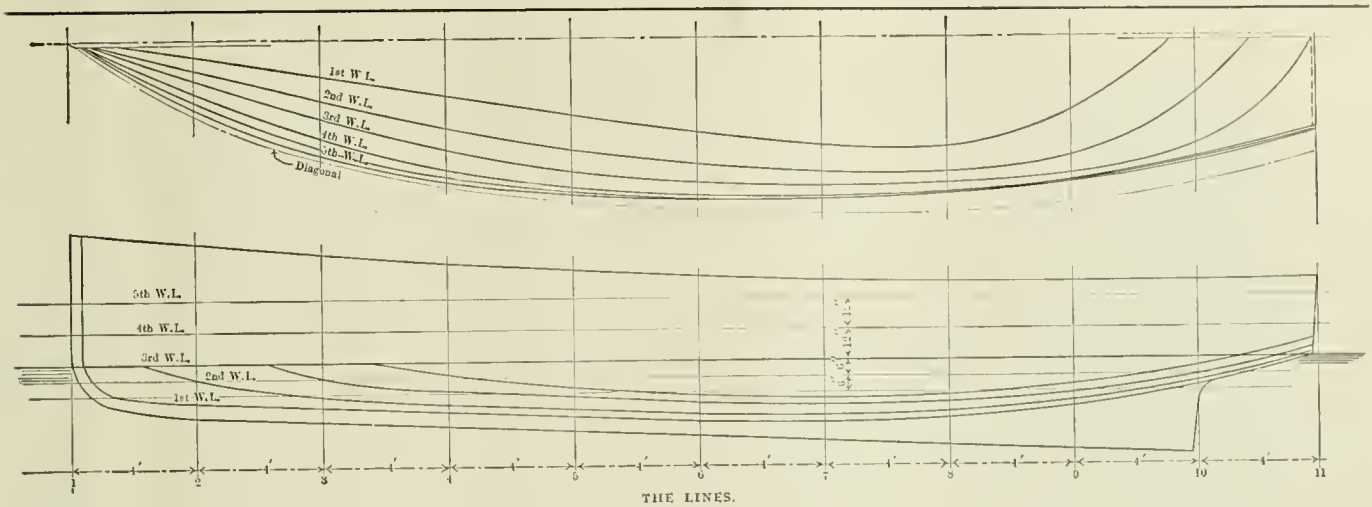
The motive power consists of a Knox two-cylinder, four-cycle, vertical gasoline engine of 20 horsepower, with cylinders of 6½ inches diameter and stroke of 7½ inches; it is fitted with a clutch and a three-bladed bronze wheel, 28 inches in diameter. The propeller shaft is of bronze, 1¾ inches diameter, passing through the shaft log, which is lined with a lead sleeve and fitted with a stuffing-box on the inboard end. The engine is fitted with a circulating pump, a bilge pump and an air pump, all of the plunger type and single-acting. The ignition is of the make and break type. A governor is fitted so as to keep the engine from racing when the clutch is thrown out, which is an excellent thing



STARBOARD VIEW OF PROPELLING ENGINE.

in making a landing. The reversing lever is at the companion-way door, so that it can be handled from the cockpit; in this way the boat can be operated by one person, who can steer and handle the engine at the same time.

The exhaust and inlet valves of the engine are made of nickel steel, and are so located as to be removable without disturbing the rest of the engine. They are interchangeable and are operated by positive drive. The cam shaft, with the cam and all gears, are located in the inclosed crank chamber, being readily



THE LINES.

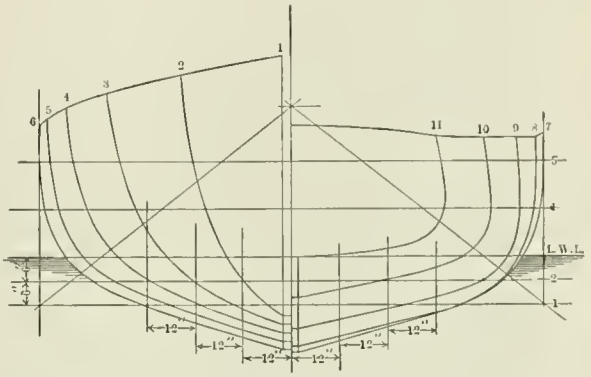
accessible on removal of the handhole plate. The gears on crank and cam shafts are of forged steel, with intermediate gears of bronze. Cylinders, heads and valve chambers are water-jacketed throughout, while the exhaust pipes are similarly treated as far as the base plate of the engine.

The reversing gear, which is mounted on the same bedplate, is operated by one lever and is housed in an oil tight case. For propulsion forwards, the reverse gear is locked, so that the gears revolve with the shaft. In reversing, the propeller may be given the same speed as when going ahead. The revolutions are 400 per minute normal, with a maximum of 500. The engine weighs complete 1,900 pounds.

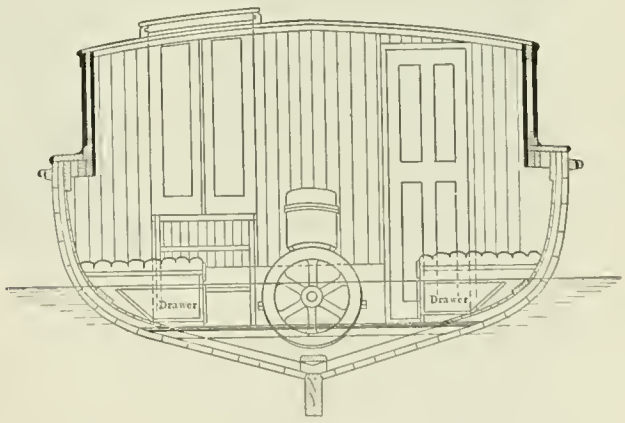
GENERAL VIEW OF THE LAUNCH.

In this launch it was the idea to get as much clear cabin as possible, and yet to have a good roomy cockpit. It will be seen that nearly all the weights are in the stern; the muffler being placed athwartship under the after deck, the gasoline tanks in the cockpit, the whistle tank, piping, and batteries, under the cockpit floor, the clothes closet, toilet room and engine—all these weights are well aft, and on a trip those on board will be in the cockpit most of the time. To keep the stern up it will be seen how full the lines had to be made aft, to allow for all the weights. They had to be spread out, and a comparatively short run given, to get the engine down as low as possible, so as not to have too great an angle on the shaft.

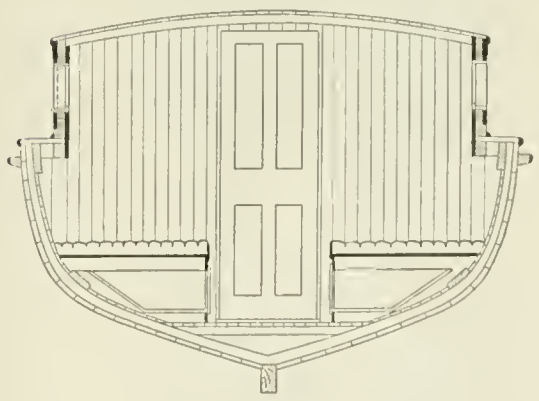
The boat runs well, handles well, leaves the water clean, makes 10 miles an hour, and is a comfortable and roomy craft for these dimensions. The name of the launch is *Bellrose*, and she is owned by O. A. Danzenbaker and Charles P. Stohlman, of Washington.



THE BODY PLAN.



MIDSHIP SECTION, LOOKING AFT.



SECTION SHOWING FORWARD END OF CABIN.

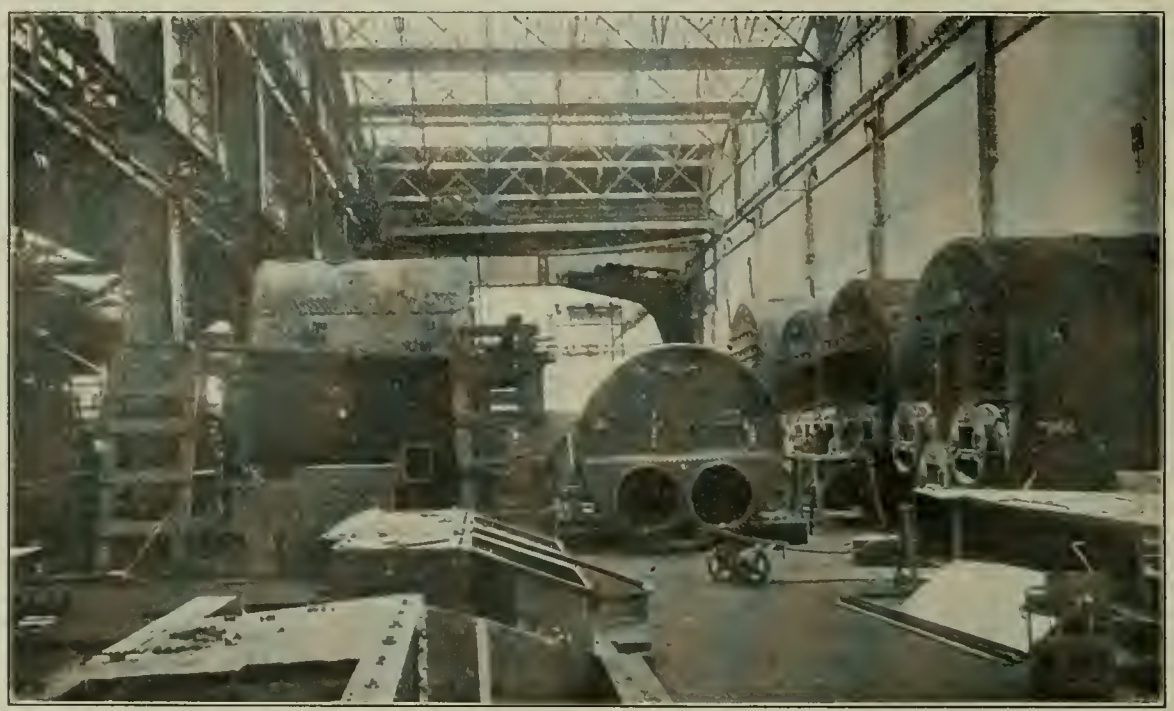
THE BOILER SHOP OF A LARGE SHIP YARD.

The maintenance of an industry in one locality for two hundred years, by one family in direct line of succession, is most unusual in the history of manufacturers. Such a record has been made by the Scotts of Scotts' Shipbuilding & Engineering Works, at Greenock, Scotland. As early as 1711 they began to build ships in Greenock, and today their descendants of the sixth generation maintain the highest traditions of the past years. Naturally the beginning of this concern was small, but today it has grown to be one of the largest engineering works in Great Britain.

These works cover an area of forty acres, and have ten berths for the construction of ships of all sizes with departments for producing all the accessories and machinery; engine and boiler works; steam turbine factory; foundries; brass, copper and sheet iron shops; saw mill and an extensive wood-working department. These give employment to over four thousand workmen.

The machines in the plate shed are designed to deal with plates up to fifty feet in length, and with angles up to sixty feet. All the tools are electrically driven. The plate straightening rolls, which have 15 to 20-horsepower reversible motors, can take plates eight feet wide. The bending rolls are driven by a 20-horsepower motor. One of the tools for drilling and countersinking plates is a three-standard drill, the spindles on which have a rise and fall of ten inches, and are fitted with automatic as well as hand feed. Nearly all the punching and shearing machines have 42-inch gaps. There is also a hydraulic stamping press for bending angles and tees, the cylinders being fourteen inches in diameter, working at a pressure of 800 pounds per square inch with a stroke of eighteen inches. The shop contains a great many hydraulic machines for joggling and scarfing the laps and edges.

The firm uses hydraulic riveters wherever possible, there being over twenty of these at work in the yard. Pneumatic tools are also extensively employed on the ships for boring, drilling,



GENERAL VIEW IN THE BOILER SHOP OF THE SCOTT SHIPBUILDING AND ENGINEERING WORKS.

Besides the boiler shop, there are other branches of the ship yard that are of direct interest to the boiler maker. The iron workers' department is extensive and important. For handling the material delivered into the yard from the railroad cars there is being installed a new 5-ton electric overhead traveling high speed crane. There are six furnaces suitable for heating shell plates of the largest size, and angles and bars for frames, etc., up to sixty feet in length. Adjacent to the furnaces are the scrieve boards and the frame bending blocks. Formerly the turning of the frames to the required curvature against the pins on the bending blocks was carried on by hand. To suit the heavier scantlings of the larger ships of the present day, a portable hydraulic machine is now used. It is fixed at its base by pins which fit into the ordinary holes of the block, and hydraulic pressure is supplied through a flexible pipe, to work the ram head against the angles, forcing them to take the desired form. This machine saves a great deal of labor, as the work is carried on in a minimum of time, and therefore at the highest heat. The bars were formerly cut to length by a guillotine, but it was considered that this had a tendency to twist the metal, and as a consequence a shearing and notching machine constructed by Messrs. Henry Pels & Company is now used.

riveting, chipping, calking, etc. There are from 130 to 140 of these tools in use on vessels in the course of construction.

THE BOILER SHOPS.

The output of the boiler shops during 1905 was practically one boiler per week, which is a testimony to the nature of the plant turning out the work. The main boiler shop, which, together with its yard, has an area of 7,000 square yards, has a height of forty-five feet to the crane rail, and is served by five overhead electric cranes ranging in lifting power up to 100 tons, besides numerous auxiliary cranes. There is a thirteen-foot gap hydraulic plate bending machine which is entirely automatic in its action, and can be set to any radius to bend plates up to two inches thick when cold. The flanging for the front and back plates of boilers is done in a hydraulic machine exerting a pressure of over 160 tons. This machine has four rams, two of which act downwards, one upwards and the other horizontally. It is served by a special hydraulic jib crane capable of lifting the heaviest plates. There are also plate edge planers and triple boring mills of corresponding power, while the vertical rolls take in plates up to ten feet in width. For the riveting of boilers, there is a thirteen-foot gap hydraulic riveting machine capable of exerting on each rivet a load of 200 tons. The weight of this

riveting machine is about 60 tons, and it is served by an independent hydraulic jib crane.

There is also a large installation in a special plant for the manufacture of water tube boilers. The amount of work done is perhaps the best indication of the equipment of this department. A set of boilers for a large cruiser can be turned out in six months; for these boilers over 24,000 tubes are required, all of which are coated electrolytically in a zinc bath.

In connection with the manufacture of large boiler taps, drill gauges, milling cutters, etc., a specially designed gas furnace has been built, with a number of compartments which can be used separately or collectively, according to the size of the tool being made.

The firm has always been noted for the rapidity of construction, especially in its engine and boiler works. A contract for the boilers and engines for twenty of the passenger steamers built for traffic on the Thames, to the order of the London County Council, was signed about December 1st, 1904, and all the twenty engines and boilers were completed by the end of May, 1905.

The Boiler Maker.

The Largest Steamers in the World.

A clipping, which purports to give a list of the ten largest steamers in the world, has been going the rounds of the marine press. The list is as follows:

Mauritania (Cunard), quadruple screw, turbine machinery	33,200.
Lusitania (Cunard), quadruple screw, turbine machinery	33,200.
Kaiserin Auguste Victoria (Hamburg-American), twin screw	25,000.
Adriatic (White Star), twin screw	25,000.
Baltic " " "	23,876.
Amerika (Hamburg-American), twin screw	22,250
Cedric (White Star), twin screw	21,035.
Celtic " " "	20,904.
Caronia (Cunard), twin screw	19,594.
Carmania " triple screw, turbine machinery	19,524.

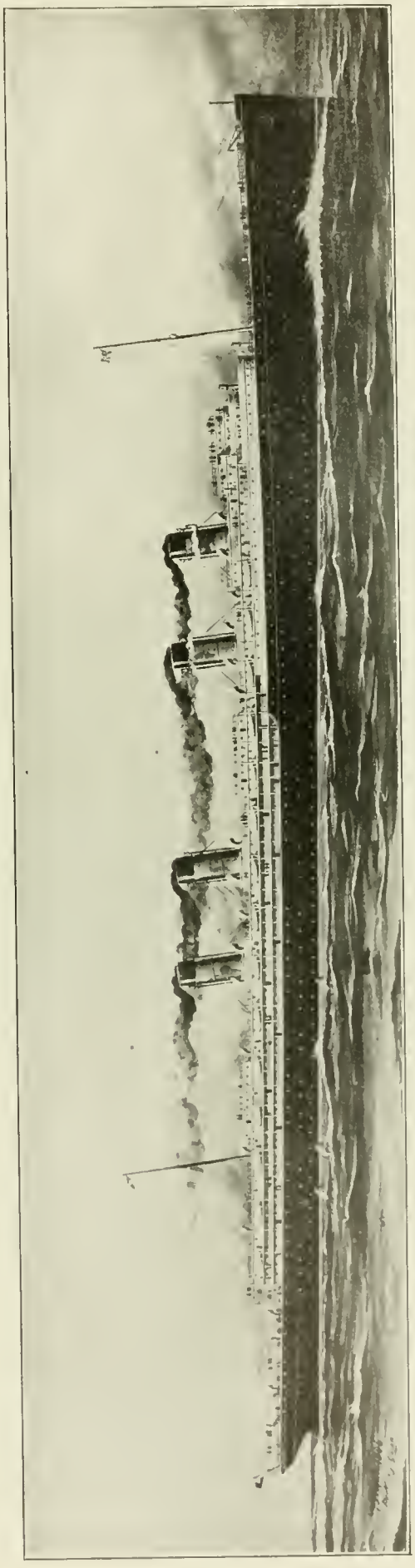
This list, which we understand originated in the office of one of our American contemporaries, is incomplete in that it failed to mention the two largest ships built in the United States, which are, in cargo carrying capacity, the largest ships afloat. Their gross tonnage is greater than that of two of the Cunarders above mentioned, though less than the other ships in the list. These vessels are, of course, the *Dakota* and *Minnesota* of the Great Northern Steamship Company, and of 20,714 and 20,718 gross tons respectively. These are twin screw ships, built by the Eastern Shipbuilding Company at New London, Conn.

THE LONDON COUNTY COUNCIL PASSENGER STEAMERS.*

BY ARCHIBALD HOGG.

The designing of suitable and economical steamers for the Thames passenger traffic at London was one of those interesting problems that every now and then come before naval architects. Had the shipbuilders been given a free hand, this problem would have afforded every opportunity for the exercise of all their knowledge and inventive faculties, but the significance of this fact does not seem to have been appreciated by the London County Council when they approached the builders for tenders, as they apparently satisfied themselves, with the minimum of external aid, as to the size and type of steamer which they gave to the builders, with hard and fast conditions as to the speed, draught of water and number of passengers to be carried, etc.,

*Paper read March 16, 1906, before North East Coast Institution of Engineers and Shipbuilders.



THE NEW CUNARDER LUSITANIA, NOW UNDER CONSTRUCTION, THE LONGEST AND FASTEST VESSEL YET PROJECTED.

that is, they practically fixed the design and dimensions of the steamers. They received in return a large variety of different proposals, which was a good indication of the difficulties in the design. Those builders whose designs most nearly fulfilled the stipulated conditions were asked to give a second tender and were each provided with copies of the same definite plan and specification of hull and machinery, giving all dimensions, thus relieving the builders from all responsibility for the successful working of the steamers. Their duty was performed when they produced the hull and machinery to the sizes given and had proved that the stipulated speed could be obtained.

Now the shipbuilder's business is to design as well as build steamers, and they usually give freely whatever design is necessary on receipt of certain information. They could therefore have been given such conditions as would have allowed them an absolutely free hand in determining the type and size of steamer. They could have been furnished with a plan of the river, showing the landings with the distances between, the speed of the river current, and also some idea regarding the probable average number of passengers to be carried over a given time, in short, all particulars affecting the running of the steamers. It may be taken for granted that scarcely two builders would submit exactly the same proposal, and the Council would thus have received, gratuitously, the valuable opinions of the shipbuilders. With this information before them they could have made a proper comparison and could have ascertained the relative economy of the steamers before embarking upon the scheme. The conditions to be fulfilled by the steamers, as fixed by the Council, were verging on the impossible. All shipbuilders know what this means as regards the first cost and the cost of running the steamers.

The Council's steamers were designed with too great a speed on the specified length of vessel and draught of water, and are consequently almost as uneconomical as it is possible to make them. The following instance illustrates how nearly the design approached the impossible limit. With the view, no doubt, of making the steamers quite up to date, the specification called for an electric light installation, the plant for which would weigh over 1¼ tons. The length of the steamer being restricted, it follows that the form of the hull must be increased in fulness in order to make up the necessary displacement. This extra fulness increases the resistance and requires an addition of about 10 indicated horsepower to the propelling machinery in order to propel the steamer at the 13 miles per hour, but this in turn means a further increase in the form, and consequently a further addition to the horsepower to propel it at the 13 miles per hour. It is probable that, at the very least, from 15 to 20 I.H.P. is used solely on account of having to carry the electric light plant. The cost of this extra propelling machinery is about £100 per steamer, or a total of £3,000, which, together with the cost of installing the lighting plant, is the actual cost incurred by fitting the electric lighting installation. And this is not all, as there is yet to add the yearly cost of the extra coal consumed, which is about £60 per steamer, or a total of £1,800 per annum, due solely to carrying the plant. Thus we see what a large price is paid and is being paid for the luxury of up-to-date lighting.

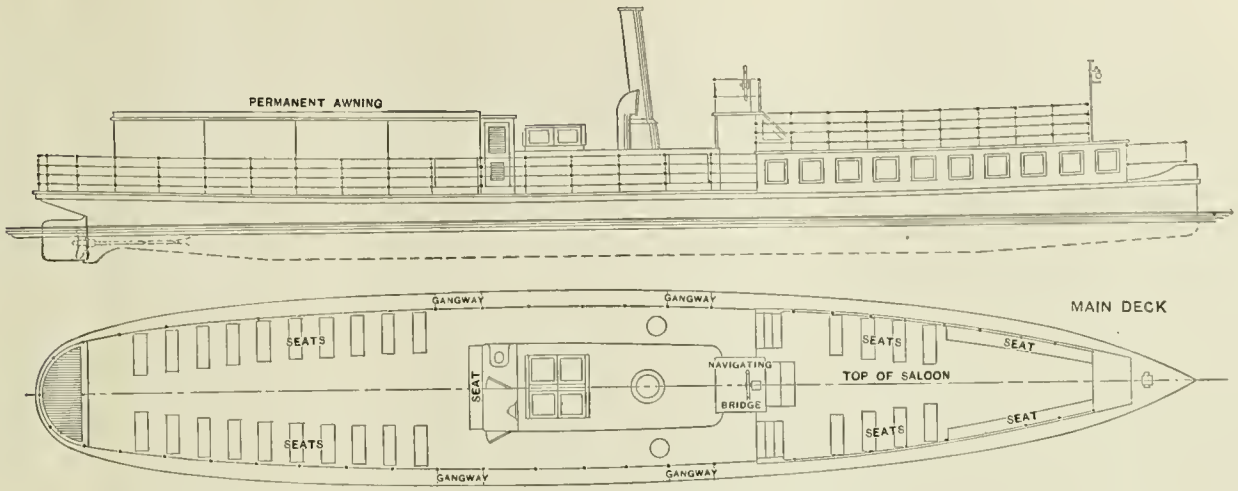
It will be readily understood that in a steamer of this nature a very considerable increase in the horsepower of the machinery is required to increase the speed by ¼ mile per hour. The specified speed was 13 miles per hour on trial, but the specified machinery proved sufficient to propel the steamer at 13¼ miles per hour. At first sight the addition of ¼ mile does not appear excessive, but when it is examined we find here another instance similar to that mentioned above. The trial results show that a smaller horsepower would propel the vessel at the 13 miles speed on the same form and displacement. This figures out at about 266 I.H.P., so that 34 I.H.P., or 13 percent, is absorbed in getting the extra quarter of a mile, which means that more weight of propelling machinery is being carried than was necessary. If the form of the hull had been fined down, reducing the displacement correspondingly, the 13 miles could have been obtained with even less horsepower, and thus a still further reduction could have been made. This goes on until a point of equilibrium is reached. This point is such that with machinery of about 230 I.H.P. the required speed of 13 miles per hour could have been obtained without altering the dimensions or the carrying power of the steamer. If this machinery had been fitted instead of the larger 300 I.H.P. engines, the reduction in the first cost would have been about £10,000, and the saving in the yearly bill for coal about £5,500 on the thirty steamers.

Another point in the design is the type of engines adopted. These steamers ply in very shallow water and consequently the hulls were constructed of material of very light scantlings, but this does not imply any weakness of the hull itself. What I call in question is the wisdom of fitting "paddle" machinery of 300 I.H.P. into hulls of such scantlings. The wear and tear due to the large engines and to their many stoppages and starts must be considerable and is bound to necessitate abnormal repairing. If screw engines had been fitted the abnormal wear and tear would have been greatly decreased and the vessels would have been equally easy to handle.

Again, with respect to the number of passengers to be carried, the London County Council fixed this at 500 and the boats were designed to carry 26 tons deadweight at a speed of 13 miles per hour on trial, with a length of steamer of about 134 feet overall, on a draught of water of 2 feet 10 inches. Assuming 3 tons for coal, etc., the remaining 23 tons weight would allow say 400 passengers on board, so that with 500 passengers on board the draught of water would be about 2 feet 11½ inches.

The given requirement of 500 passengers fixes the deck area independent of any question of draught of water, and thus the decisive factor in this design is the question of economic propulsion. The constant obtained by the Admiralty formula, $\frac{D^{\frac{2}{3}} \times V^3}{P}$, is a sure guide to the economy of the design, and in these paddle steamers it works out at a little over 130. Now this is not an economical constant for a steamer which has to do such work, and at the early stages in the proposal this fact should have received consideration, with a view to modifying the design of steamers, to carry fewer passengers at a lesser speed.

The type of steamer required for work in the Thames is not really what is usually understood by the term "River Passenger Steamers." Consequently, a vessel having a capacity similar to that of a street car, or rather larger, with a service at frequent intervals between the landings, would perhaps be more likely to meet the requirements of the traffic. Such a steamer is illustrated here. The dimensions are: Length, 90 feet between perpendiculars; beam, 13 feet; depth, 5 feet; and the vessel has one deck only for passengers, except in way of the saloon, which is sunk into the hull, with a raised roof upon which passengers may sit. Twin screw propellers are used instead of paddles, thus saving the weight of paddle boxes, sponsons, etc. This steamer would carry 150 passengers at a speed of 12 miles per hour with about 75 I.H.P. on a draught of water of 2 feet 10 inches, while the deck area provided allows for a maximum of about 200 passengers. It is probable that, while employing the same number of boats, they would carry, on an average, as many passengers as the present boats do. They would cost less and would be much more economical in the consumption of coal, etc. The saloon could be lightly panelled and the seats upholstered with cushions, while some of the steamers could be fitted with refreshment bars. Thirty of these steamers would cost about £95,000 less than the present boats, the yearly coal bill would be about £17,500 less, the other expenses, including insurance, would be correspondingly reduced, and the cost of upkeep repairs would be greatly curtailed. If thirty steamers were not sufficient to meet the traffic at certain times more vessels could be added. The fleet would be much more manageable with a larger number of smaller boats, and could be increased or curtailed as desired, which it cannot be at present without seriously



GENERAL ARRANGEMENT DESIGN FOR RIVER THAMES STEAMERS.

impairing the service. These ninety-feet boats are suggested as the largest size that should have been utilised, but it is probable that much better results might be expected from still smaller vessels.

THE NEW CARGO CARRIER BELLEROPHON.

New Type Cargo Liner.

An extremely interesting cargo steamer has just loaded at Glasgow for China and Japan, which merits some description as an example of the latest development in cargo boats. This steamer, the *Bellerophon,* is the sixteenth built and engined by Workman, Clark & Co., Limited, Belfast, for the Ocean Steamship Company, Limited, of Liverpool. She is unique in that she has no masts for carrying rig. Instead, she has four tall pillars, two abreast forward and two abreast aft, for carrying derricks. Between the two forward posts a bridge is fitted near the head for lookout purposes.

The *Bellerophon* is of 9,000 gross tons, and has been specially designed for trade to the far east. The holds are so arranged as to be clear of obstructions, in order to admit of the carriage of cargo of the most bulky character, such as machinery. In lieu of stanchions the decks are supported by strong fore and aft girders. There are seven holds, each of them being entered through large hatchways. For handling the cargo there are twenty-six powerful steam winches and derricks, while other appliances of the most approved type are provided, so as to deal with a full cargo in the most expeditious manner.

Although primarily a cargo boat, accommodation for a number of emigrants is provided in the forecastle and upper 'tween decks, with all the necessary conveniences. Accommodation for the officers and engineers is provided in a large steel four-story deckhouse amidships, and for petty officers in a deckhouse abaft the engine casing. These apartments are exceptionally large, and are comfortably furnished. The seamen's and firemen's quarters are in a steel deckhouse at the after end of the upper deck and at the after end of the main deck respectively. The vessel is lighted throughout by electricity, the installation including large cargo clusters, mast lights, and a powerful search light, fitted on the forecastle head, for use in the Suez Canal.

The propelling machinery consists of two sets of the latest type of triple expansion engines, complete with all necessary auxiliaries, supplied with steam from double-ended, multi-tubular boilers, working under the closed ashpit system of forced draught.

Before proceeding to Glasgow to load general cargo outwards for China and Japan the *Bellerophon* had a series of highly successful speed and other trials in Belfast Lough. The capacity of the cargo working appliances was thoroughly tested in the case of some very heavy castings which had to be taken on board, made by the Steel Company of Scotland for the dockyard at Nagasaki. These heavy lifts were handled by the *Bellerophon* with the greatest ease. Two more of this type of vessel are being built by Workman, Clark & Co., and a fourth by D. & W. Henderson & Co., at Glasgow.

Benjamin Taylor.

MOTOR BOATS, XII.

BY DR. WILLIAM F. DURAND.

LAYING DOWN AND ASSEMBLING.

Having thus considered the structural elements best suited to the construction of small boats, a few points may be noted in connection with the actual process of preparing and assembling these elements into the completed structure.

The first step will be to lay down the water lines and the sections at each frame full size on the floor or mold loft. The ordinates for these lines are taken from the lines as designed, and the resulting full sized lines are faired up in the same general manner described in connection with the operation of design. It must not be forgotten that the lines as commonly laid down on the drawing board relate usually to the outside of the frame or inside of the skin. In such case they are immediately available for determining the form of the frames. Some designers, however, prefer to lay down the lines to represent the actual water surface of the boat, and in such case the thickness of the planking must be taken off all along the section line in order to obtain the form for the frame.

If we assume that the boat is of moderate or small size and is to be built over fixed molds, the next step will be to determine the form of the molds. Not less than five such molds should be used in addition to the stem and stern post or form, and in some cases a still larger number will be found advantageous. The form of the mold is to be taken from the full sized sections, one-half on a single board, selected of width sufficient for the purpose, and this used as pattern for a duplicate, the two then being put together as in Fig. 57, thus forming the mold complete.

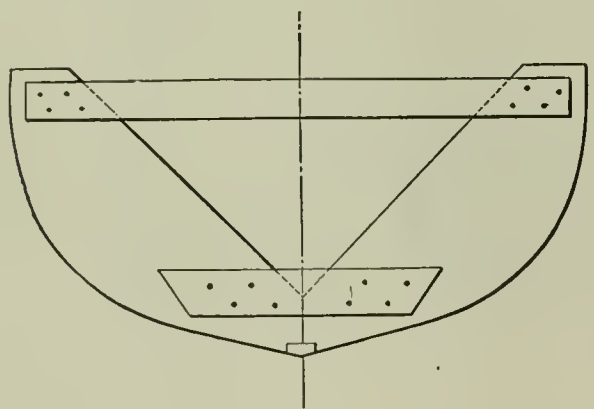


FIG. 57.

The form of the half section may be conveniently transferred from the floor to the board by laying down nails with their heads on the line of the section and the body standing at right angles. The board is then laid down on the nails and lightly pressed or struck with a hammer, thus making an imprint of the nail heads on the under side. A batten sprung through these will then give a satisfactory reproduction of the line on the board, and the mold may be cut to this line. Points showing the vertical center line are also noted, and from the half mold thus determined its mate is cut, and the two are joined as indicated in Fig. 57. The other molds being made in the same manner, the entire series is ready for assembling on the keel. The keel support may then be prepared, consisting of a two-inch plank blocked up on edge, and with the upper edge cut to fit the sweep of the keel. This plank, which is, of course, no part of the boat proper, makes a convenient and secure foundation for the further construction of the boat. It will be found a convenience to so adjust this support as to bring the designed water line of the boat horizontal.

Keel, Stem and Sternpost. These items may next be gotten out to dimension, and suitably rabbeted to take in the edge of the garboard strake of planking and the ends at the stem and stern. They are then erected in place on the keel support, and secured together with chocks and through fastenings after the manner indicated in the various illustrations showing structural features of this character.

Deadwood and Shaft-log. With the old form of stern the deadwood and shaft-log may next be gotten out and fitted in place. The shaft log is usually formed by a pair of timbers secured by through bolts, and provided with a longitudinal hole of size suitable for the shaft tube, and within which the shaft will ultimately find its place.

In the framework throughout, and especially in these longitudinal members, the joints between the timbers should be made tight with white lead and drawn close by means of through fastenings wherever possible.

Molds. The molds, made as above noted, may now be erected in place, centered and squared with the keel, and then secured by bracing and ties.

Ribbands. These are strips which are bent over the molds and lightly secured to them from one end to the other along the planking lines. These will serve to further secure the molds in place, and will also indicate any unfairness in the lines, should such exist. It will be an advantage to make the molds of sufficient height so that the upper ribband may be put on clear of the location of the sheer strake, thus providing a line of support for the frames until the sheer strake and clamp piece are secured in place. In small boats, furthermore, the ribbands are readily made of sufficient size and number to permit the frames to be bent into place against them and thus formed without the use of frame molds or bending floor.

Frames. The material for the frames may next be prepared, and the frames bent to form and secured in place. As noted above, small frames may be bent directly in place against the ribbands. After being properly sized, the frame is steamed and then taken directly to place and bent to form, secured to the keel, clamped to the ribbands and carefully adjusted in place. For heavier construction, where the frames cannot be readily bent against the ribbands, they are commonly brought to form on the bending floor. To this end the form of the frame on the inner or concave side is transferred in any convenient manner to the floor, and holes are bored along the inner edge, into which pegs are driven and against which the frame is then readily bent to form. In some cases, however, special molds are cut out for each frame and used as a foundation on which to bend the frame to form. Where the form of the frame will permit, it should run continuously from rail to rail, without joint at the keel. This however will be practicable only amidships; while forward and aft, where the angle at the keel is sharp, the frame will be made in two parts, secured together by a chock at the bottom. In either case, after being bent to form, the two sides of the frame are secured by cross ties so that it will retain its form when erected in place in the boat. When adjusted in place the frames may be secured permanently to the keel and temporarily to the ribbands. The fastening to the keel will include the fitting of chocks or bent floors with keelson, somewhat as indicated in Fig. 50.

Planking. This is to be gotten out in as long lengths as possible, tapered toward the bow and stern so as to carry the same number of strakes all the way fore and aft, and maintain as far as possible the planking edges at right angles with the frames.

Where the planking is double, the outer layer must be so arranged as to shift joints with the inner layer. The outer surface of the latter may be painted with thick white lead with special attention to the end joints and seams, and the joints and seams of the outer layer should be made with the same or

equivalent material. This will give a white lead filling in all joints and seams and between the two layers, which will serve effectively to make a watertight job of the planking as a whole.

The ribbands are, of course, removed in order to make way for the planking, except in the case of the upper ribband, which, as noted above, should be carried high enough to clear the sheer strake and clamp piece. After the latter are fitted and secured in place a few ties may be run across from one side to the other, the upper ribband removed, the tops of the frames sawn off, and the molds removed. The rail may then be finished as desired, either left as formed by the combination of sheer strake, clamp and frames, or with the space between the frames filled in, or with a cap piece covering over the sheer strake, clamp and space between.

Bilge and Side Stringers. In all first class construction and in all but the smallest boats, these should be fitted as a general addition to the longitudinal strength and stiffness of the boat.

Engine Bed. The general principles relating to the installation of the engine bed have been already discussed. The details will depend on the special design of the engine. Special precaution should be taken to avoid making it too short or too light, and particularly in high-powered boats, too great care can not be taken in so arranging the engine bed as to call into play the maximum amount of boat structure.

Seats. Whether the seats are run fore and aft or athwartships they should be supported on the skin of the boat by a suitable stringer piece run on the inside of the frames and secured to them. The seat should then be carefully secured to the supporting stringer in order that it may act as a tie or brace for the side of the boat. Transverse seats thus fitted give the boat great lateral strength, acting as ties or struts as occasion may demand, while a longitudinal seat fitted in the same manner will act in effect as a powerful side stringer, adding in marked degree lateral stiffness to the side of the boat. With fore and aft seats, the inner edge is of course carried on posts extending down and carried on a stringer piece attached to the frames. In some cases chocks are fitted under the seats to give added racking strength to the boat.

Deck Beams and Decks. Deck beams and decks over the covered spaces may be fitted next, not forgetting the installation of gasoline tanks or of any such feature which is to go in before the space is finally closed.

Planing and Finishing Exterior. After the preceding work is completed, the work of planing and finishing the exterior may be taken up. The planking is first rough planed, and the joints are then calked and filled with thick white lead or similar material. The surface may now be finally planed and smoothed up and made ready for painting and puttying. Much will here depend on the eye. The relatively thin planking will not permit the removal of any great thickness in order to fair up a part of the surface which may seem too high, and in order to realize the best result as regards external finished form, great judgment and care will be required. These facts call all the more emphatically for special care with the form during the earlier stages, and before it is too late to change the molds and correct any irregularities which may exist. If this part of the work is well done the form of the boat will, under the plane, scraper and sandpaper, come out smooth, continuous and pleasing to the eye.

Where the planking is worked in a double layer, the calking is unnecessary, though with thick planking it is sometimes employed. With thin planking, such as ¼ to ⅜ inch thick, however, it would be found very difficult to make the seam retain the cotton. For this reason, among others, when very thin planking is to be used it must be worked in double thickness with shifted seams, thus obviating the need of a calked joint.

In painting, three or four coats will be none too many, rubbed down somewhat between each coat, and with plenty of time for drying allowed. This, if well done, will give an outer surface smooth, hard and durable. Below the water line some good marine or anti-fouling paint may be used, while above, good white lead, or color in a white lead base, is to be recommended.

Thus far the type of construction more especially in view is the small boat made over molds and with dead-wood and the old form of stern. With larger boats of the same general type the frames will be heavier and stiffer, and the use of molds is no longer needful or common. The frames are prepared, bent to form and secured in place all in the same general manner as described. This operation being completed, the boat is then "in frame," and the planking and other structural and finish features are carried out along the same general lines as for the smaller type of construction.

For boats with the torpedo-boat or modern stern, the constructive operations are of the same general nature, and involve the same underlying principles as for the older type. With the modern stern the keel is usually flat rather than bar-formed —the more common style of keel with the older stern. These differences are shown in the various structural views.

A further item of difference is found in the dispositions suitable for taking care of the shaft and shaft tube where it passes through the bottom of the boat. Suitable material must be provided at this point, as indicated in the structural cuts, in order to properly secure the tube to the boat and give adequate support to the shaft. In addition to the bearing for the shaft where it passes through the bottom of the boat, there will also be required an additional support at the extreme end of the same, just forward of the propeller. This is usually in the form of a hanging bracket formed of structural steel or cast bronze, and supporting a suitable bearing for the shaft, the general arrangements being indicated sufficiently in the various illustrations.

The style of boat construction in view throughout these suggestions is of the plain normal type, such as is met with in the average small or moderate sized motor boat, and where no special requirements involving extra speed or lightness are in question. For such special cases various structural features, including special methods of framing, extra thin planking with or without varnished fabric between, etc., have been noted at an earlier point, and will not require further mention here.

These brief hints regarding practical boat construction are furthermore intended only to outline the general processes, chiefly as illustrative of the principles dealt with at an earlier point, and as indicating to the non-technical reader the general routine of operations which may be followed in work of this character. It must be understood that there will be a vast number of problems of fitting, adjustment and procedure, with which the practical builder must deal as best he may, and which can not be covered in any written description of such work. Details of construction must vary with the particular features and requirements of the case, and in these pages no more is intended than to give some notion of the underlying principles involved, with sufficient illustration of their application to stimulate an intelligent study of such problems on the part of those who may be brought into contact with them.

The world's record in gunnery has been established on the battleship *Ohio* by D. M. Dean, whose score was thirteen bullseyes out of thirteen shots in one minute, with a 6-inch gun. The *Ohio* was steaming at 10 knots at the time, and the target was distant 1,600 yards. The best previous record for this size gun was eleven hits out of fourteen shots, made by one of the gun pointers in the British navy. When it is realized that as recently as the Spanish war the 6-inch guns, as fitted on the *Oregon*, were capable of only about two shots per minute, the importance of this record and the immense forward strides which it indicates become all the more apparent.

INTERNATIONAL MARINE ENGINEERING

Published Monthly at
17 Battery Place - - NEW YORK
By MARINE ENGINEERING, INCORPORATED
H. L. ALDRICH, President and Treasurer
8 Finsbury Square - - London, E. C.
E. J. P. BENN Director and Publisher

PROF. W. F. DURAND, Advisory Editor

SIDNEY GRAVES KOON, Editor

GEORGE SLATE
Vice-President and New York Representative

Branch Offices: Philadelphia, Pa., Machinery Dept., the Bourse, S. W. Anness.
Boston, Mass., 170 Summer St., S. I. Carpenter.
Chicago, 34 Clark Street, Howard S. Moss.
Midlands, 2 Sandhurst Road, Moseley, E. E. Starke.

TERMS OF SUBSCRIPTION

	Per Year	Per Copy
United States, Canada and Mexico	$2.00	20 cents
Great Britain and Ireland	10/6	1/
Other countries in the Postal Union	10/6	1/

Entered at New York Post Office as second-class matter.
Copyright, 1906, by Marine Engineering, Inc., New York.
International Marine Engineering is registered in the United States Patent Office.
Copyright in Great Britain: entered at Stationers' Hall, London.

Notice to Advertisers.

Changes to be made in copy, or in orders for advertisements, must be in our hands not loter than the 5th of the month, to insure the carrying out of such instructions in the issue of the month following. If proof is to be submitted, copy must be in our hands not later than the 1st of the month.

The edition of this issue comprises 6,500 copies. We have no free list, accept no return copies and issue only enough to supply the regular demand.

Shipbuilding and the Merchant Marine.

The arrival in the port of New York during the last six weeks of three important new ships belonging to as many transatlantic lines flying the flags of European continental nations has served to emphasize the immense importance of the passenger and freight traffic on the North Atlantic, between the port of New York and the ports of Great Britain and the north of Europe. We pointed out in our issue for December last that there were at that time under construction, or had recently been completed, for European ship owners, to be used in the New York trade, no less than ten immense steamships, the aggregate tonnage of which was more than two hundred thousand. Of these ten, five have already made their first voyages, while the others are expected at some time within the next year.

As our readers are well aware, it is a matter of extreme humiliation to Americans that ships flying the flag of the United States have so little a share in this great enterprise. There has not been constructed for several years an American ship for the North Atlantic trade and there appears to be little prospect of any such construction for a number of years to come.

At present about 11 percent of our imports and exports by sea is carried in American bottoms, the remaining 89 percent being transported mainly by English, German and Norwegian vessels. It goes without saying that no one nation can conserve to itself with any propriety or regard for the rights of others its entire carrying trade. It will not be questioned, however, that as a general proposition each nation is entitled to about 50 percent of its carrying trade. This figure is based on the fact that all exports and imports are necessarily mutual propositions as between two countries, and each is legitimately entitled, from a theoretical standpoint, to an equal share in the transporting of such commodities.

It is needless to remind our readers that there is at present before congress a bill looking toward the improvement of such conditions from the American point of view, although the provisions of this bill do not contemplate any action with regard to the North Atlantic. A considerable number of new shipping lines is aimed to be established between the United States and the east and west coasts of Central and South America. These are urgently needed, because of the fact that it is not now possible to make direct mail connection with Brazil or the Argentine Republic except by very slow and infrequent ships, and with a service not at all satisfactory. As a matter of fact, both Brazil and the Argentine Republic are as near to Liverpool as they are to New York, but they are not as near New York by way of Liverpool as they are to New York direct, yet nearly all important business has to go by this circuitous route in order to be taken care of with any degree of celerity or regularity. The establishment of these new lines, with steamers of fair speed and absolute regularity of sailing, ought to do much toward fostering the trade of the United States with her southern neighbors, and as such ought to redound very largely to the benefit of American manufacturers and exporters.

The Big Battleship Craze.

Since the English battleship *Dreadnought* was projected, and particularly after the great interest was developed at the time of her launching, other powers have fallen into line with projects for battleships of equal or greater displacements, and there seems to be no disposition to spare expense in the carrying out of programs involving these immense ships. The German proposition calls for ships of 19,000 tons as against 18,500 in the *Dreadnought;* the French have under contemplation three ships of 18,000 tons each; the Japanese are reported to have already under construction in their own yards two ships which are variously

reported as from 19,000 to 22,000 tons each; the United States program includes one ship, the details of which are left to the Navy Department, but which seems likely to reach the 20,000-ton mark; while the Russians have an ambitious program involving among other things nine ships of 16,900 tons each.

There is no doubt that with the increasing displacements the amount of military value possible to be put into a ship is increasing in an even higher ratio. This is due to physical causes into which it is unnecessary to enter here. On the other hand, these immense ships lack handiness, mobility and general adaptability to diverse circumstances in such degree that it seems to us a mistaken policy to carry the matter to such extreme dimensions. During the last three or four years, there seems to have been a general policy for the maximum of design to crystallize at about 16,000 to 16,500 tons, and on this displacement excellent ships have been designed, more powerful in every way than was any ship engaged on either side in the Russo-Japanese war, upon the results of which war the new designs are said to be based. Equal fighting capacity cannot be obtained in a 16,000 ton ship as compared with one of 18,000 or 20,000 tons; but for equal expenditures from the national exchequer there is little doubt that the results obtained with the smaller ship will be equal in all essential particulars, and superior in many, to those obtained with the immense constructions into which the naval powers are now rushing with such abandon.

Naval Comparisons.

Much uncertainty has been manifested regarding the relative strength of the French, the German and the American navies, each of which has been severally claimed to occupy second place among the war fleets of the world. A satisfactory basis of comparison as between individual ships, and between groups of ships, and entire navies has yet to be found. Many methods of procedure have been proposed at various times, and have had more or less evidence of good sense in their make-up, but no method has been devised which will give in any way a conclusive comparative result as between two ships of approximately equal power, but dissimilar in the several elements of battery, protection, speed, steaming radius, handiness and general adaptability which go to make up that power.

As a general proposition, when it comes to a question of comparing entire navies, the most satisfactory of the numerous processes which has come to our attention is one basing the result upon displacement in the several classes of ships. This, however, in order to be generally applicable, must necessarily take account of the several dates of construction of the ships, and must discount ships the age of which is such as to make it certain that their elements of naval value are necessarily inferior to those possessed by ships of a later date. This method of comparison assumes that the naval architects designing the various ships are of equal ability, which is by no means always the case. It assumes, furthermore, that the problem of design has been carried out in approximately the same manner in one ship as in another, which is also not usually the case. It has, however, the beauty of simplicity, and certainly does give a general idea upon which deductions may be based. In the absence of a satisfactory scientific substitute, this method is perhaps the best one to be employed.

An article in this issue compares the French navy with the German, and a supplement has been given showing how the American navy compares with the other two. It should be noted that this comparison is based on displacement and gun power alone, without any effort to discount the older ships in any way, and as such the results should be considered as approximate only.

The Lengthening of Steamers.

Two or three years ago there seemed to be a sort of epidemic, on the Great Lakes, of lengthening the freighters which had been somewhat outgrown in size by later competitors. The peculiar form of Lake ships, with long parallel middle bodies, adapts itself readily to this method of operation, and as the loading and unloading docks are provided with facilities in multiple stationed just 12 feet apart, the additional length was necessarily made in multiples of 12 feet, a common figure being 72 feet.

This process has not been carried on to so large an extent on the seaboard, partly because of the fact that the forms of the ships are not so readily adaptable to this procedure, and partly because it has been found more advantageous in most cases to continue to operate the old ships or to substitute new ones for them. The Old Dominion Steamship Company, however, has recently lengthened several of its ships, removing from service one at a time, and the description in this number of the lengthening of the *Hamilton* gives a good general idea of the operation. The reason given for having adopted this method to increase the carrying capacity of the fleet, rather than to have constructed new ships, is one based purely on commercial grounds, and is a good exhibition of the sound policy usual prevailing in such matters.

The operation of actually separating the parts of a ship a given distance, and leaving them so perfectly in line that the new material can be erected into position without in any way disturbing the lines and form, is a very delicate one, but it is not on record that any difficulty has been experienced in carrying out this program with entire satisfaction to all concerned.

ABSTRACT FROM RULES AND REGULATIONS OF BUREAU VERITAS.

EDITION OF 1905.

ARRANGED BY HARRISON S. TAFT.

PART II.

9. Bilge and Floor Keelsons. Side Stringers.

1. Bilge Keelsons

(*a*) A keelson consisting of two angle bars riveted back to back is to be fitted at the lower turn of the bilge in all vessels except in way of a continuous or partial double bottom. In vessels of 14 feet or more in depth a similar keelson is also to be fitted at the lower turn of the bilge. Said keelsons are to extend as far forward and aft as possible.

(*b*) When the depth of a vessel is 25 feet and over, a bulb plate is to be fitted to the lower bilge keelson for ⅔ length amidships. In all vessels of 14½ feet depth and over, a bulb plate is to be fitted to the upper bilge keelson for ⅛ of vessel's length forward, but it should extend aft so as to scarph with the amidship bulb when fitted to the lower bilge keelson as stated above.

(*c*) For arrangement of upper bilge keelsons see table 3.

2. Floor Keelsons.

(*a*) A keelson consisting of two angle bars riveted back to back embracing the top edge of intercostal plates is to be fitted on top of floors midway between the center line and the lower bilge keelson in vessels over 32 feet in breadth or over 275 feet in length; also in all three and spar deck vessels.

(*b*) The angle bars are to extend forward and aft as far as possible; the intercostal plates for the ⅔ length amidships. The intercostal plates are to be secured to the shell in all cases by a single clip equal to the reverse frames, and with a similar clip to the floors whenever said floors amidships are 22 inches in depth at center line.

(*c*) When said intercostal plates are not required, wash plates must be fitted, being of the same weight as the lower part of watertight bulkheads and extending for ⅔ length amidships. They are to be secured to the floors by angle clips. If a vessel of less than 26-foot beam has an intercostal or a continuous vertical center line keelson, said wash plates need not be fitted.

3. Side or Hold Stringers.

A hold stringer is to be fitted midway between the upper bilge keelson and the lower tier of regular deck beams; all as indicated in table 3.

4. All keelson and stringer angle bars are to maintain their midship scantling for ⅔ length amidships. Fore and aft of said ⅔ a reduction of 1/16 in thickness will be allowed in all angles of and over ⅜ inch thick.

5. The distance on the girth of the frame from the bilge keelson to the hold stringer or from hold stringer to hold stringer is not to exceed 6 feet.

6. The smaller flange of all longitudinal angle bars is to be secured to the frames or reverse frames, except for middle line keelsons, where the larger flange is to lay horizontally, with the smaller flange standing vertically.

7. In vessels navigating in ice, additional double angle bar keelsons must be fitted forward not more than 4 feet apart.

10. Floor Clips.

1. Angle clips are to be fitted on top of all floors and on all frames in way of all angle or plate stringers, to which the stringer angles are to be riveted. Said angle clips need not be fitted when intercostal plate keelsons, connected to the shell and to the floor plates, are adopted.

2. When bulb angle frames are adopted two angle lugs are to be fitted in the way of all keelsons and stringers. One lug may be used if of sufficient size to admit of 4 rivets in the keelson angle and three in the frame. In way of intercostal keelsons one lug only may be used.

11. Continuity of Keelsons.

When the continuity of keelsons or stringers is interrupted at bulkheads, gusset plates of the same thickness as the keelson angles must be fitted on each side of said bulkheads and riveted to each other so as to maintain the strength of said keelsons. When keelsons are worked continuous through a bulkhead, watertight collars must be fitted thereat.

12. Plate Side Stringers in Holds and Hold Beam Stringers.

1. All of said plate stringers are to be secured to the shell plating by angle clips worked intercostally between the frames, with a continuous angle bar worked at the face of the frames, said face bar being riveted to the reverse bars and reverse clips on the frames.

2. The stringer plates are to be supported by plate brackets worked on alternate frames whenever the beam spacing exceeds two frame spaces.

3. All stringer plates are to be worked continuously through all watertight bulkheads and are to be connected to a breast hook at each end.

4. When any holes are cut in a stringer plate for pipes, etc., compensation must be made for said holes.

5. The width of the stringer plates is to be measured from the inside edge of the frames except when the plates are not cut by the frames, in which case they are to be measured from the shell plating.

6. The midship scantling of the stringer plates is to be maintained for ½ length amidships; that of the angle bars for ⅔ length amidships. A reduction of 1/16 in thickness will be allowed in angles of and over ⅜ inch thick beyond said ⅔ length.

TABLE 3.—ARRANGEMENT OF DECK BEAMS, BILGE KEELSON AND HOLD STRINGER.

Type of Ship	No. S. H. B. Tiers	Molded Depth to Upper Deck Amidship to Second Deck In Awning Deck Vessels	TYPE OF UPPER BILGE KEELSON AND HOLD STRINGER	
			Upper Bilge Keelson	Hold Stringer
One Deck Vessels	None	Feet under 12	—	DA
		12 " 13	—	DA+IP
		13 " 14	—	12" PS+SFB
		14 " 15	DA	15" PS+SFA
	One	15 " 16	"	PS+SFA+SHB
		16 " 17	"	"
		17 " 18	"	PS+DFA+SHB
		18 " 19	"	"
		19 " 20	"	PS+DFA+FP+SHB
		20 " 21	DA+IP	"
		21 " 22	DA	a "
Two Deck Vessels	None	22 " 23	"	DA+IP
		23 " 24	"	PS+SFA
	One	24 " 25	"	PS+SFA+SHB
		25 " 26	"	"
		26 " 27	"	"
		27 " 28	"	PS+DFA+SHB
		28 " 29	DA+IP	"
		29 " 30	DA	a PS+DFA+FP+SHB
		30 " 31	"	b "
Three Deck Vessels	None	31 " 32	DA+IP	DA+IP
		32 " 33	DA	PS+SFA
		33 " 34	"	"
		34 " 35	"	PS+DFA
	One	35 " 36	DA+IP	PS+SFA+SHB
		36 " 37	"	"
		37 " 38	"	a PS+DFA+SHB
		38 " 39	DA	PS+DFA+FP+SHB
F	S	39 " 40	"	DA+IP
		40 and above	—	—

F=Four Deck Vessels; S=Special Consideration; DA=Double Angles; IP=Intercostal Plate; PS=Plate Stringer; SFA=Single Face Angles; DFA=Double Face Angles; FP=Face Plate; SHB=Strong Hold Beams; Plus Sign (+) Means "With a."

a. An additional double angle bar stringer between hold stringer and upper bilge keelson

b. An additional double angle bar and intercostal plate stringer between the hold stringer and upper bilge keelson.

Deck beams spaced 2 frame spaces apart.

Stronghold beams " 10 " " "

13. Web Frames in Engine and Boiler Space.

1. All steamers of 15 feet or more in depth are to have web frames fitted in their engine and boiler compartments and also in athwartship coal bunkers within range of same. The web frames are to be spaced two frame spaces closer than given in table 4.

2. They are to extend to at least the height of the crown deck of the compartments they are fitted in.

3. Deep framing may be substituted for web frames, in which case said framing must be ½ inch deeper and ⅛ thicker than given in table 5.

14. Web Frames with Side Stringers in Lieu of Hold Beams.

1. Said web frame plating is to be of the same thickness as the flange of the frame bar to which it is attached. Double reverse bars are to be worked on the inner edge of said plate.

2. The web frames are to extend from the deck above the tier of beams dispensed with to the floors. In no place shall a web frame floor be of less width than the width of the web frame. They are to be secured to their respective deck beams by large plate brackets. If a web frame does not come at a beam, bracket plates must be worked on both sides of the deck stringer plate in way of said web frame.

3. The side stringers are to be of the same thickness and width as the web frames and in general have double angle bars of frame size on their inner edge. (See table 4.) When the frames are deeper than ordinarily required the side stringers must be of increased thickness to compensate for the extra reduction in cross section at frames.

4. The side stringers may be worked continuously through or intercostally between the web frames. In either case there is to be a double angle clip of reverse bar size and diamond plate connection at the intersection of the web frames and stringers.

5. SAILING VESSELS.

When said vessels are 23 feet and more in depth to the upper deck two web frames should be fitted in way of each mast on each side of the vessel. Said webs should extend to the deck stringer connected to the sheerstrake to which the chain plates of the lower rigging are riveted. Said web frames may be omitted if a bulkhead is fitted at mid-length or other forms of strengthening are adopted in way of said masts.

15. Deep Framing in Lieu of Web Frames.

1. When deep framing is adopted in lieu of web frames, the depth of said framing is to be as found in table 5. Said framing is to extend to the lowest tier of regular deck beams.

TABLE 4.—WEB FRAMES IN LIEU OF HOLD BEAMS.

Single Deck Vessels							Multiple Deck Vessels							
Type	Web Frames		b. Plate Side Stringers				No. of Deck Tiers	e. Depth to Lowest Deck	Web Frames		Plate Side Stringers			
a. Molded Depth to Upper Deck amidships To Second Deck in Awning Deck Vessels	Depth Inches	Spacing Frames	Number	Face Angles Upper	Middle	Lower			Depth Inches	Spacing Frames	Number	Face Angles Upper	Middle	Lower
Feet								Feet						
15 under 16	13	8	Two	SA	—	SA	—	—	—	—	—	—	—	—
16 " 17	13	8	"	"	—	"	—	—	—	—	—	—	—	—
17 " 18	14	8	"	"	—	DA	—	—	—	—	—	—	—	—
18 " 19	14	7	"	DA	—	"	—	—	—	—	—	—	—	—
19 " 20	15	7	Three	SA	DA	SA	—	—	—	—	—	—	—	—
20 " 21	15	6	"	"	"	DA	—	—	—	—	—	—	—	—
21 " 22	16	6	"	DA	"	"	—	—	—	—	—	—	—	—
22 " 23	17	5	"	"	"	"	—	—	—	—	—	—	—	—
23 " 24	18	5	"	"	"	"	—	—	—	—	—	—	—	—
24 " 25	17	6	"	"	SHB+SFA	"	—	—	—	—	—	—	—	—
25 " 26	18	6	"	"	"	"	—	—	—	—	—	—	—	—
26 " 27	18	6	"	"	"	"	—	—	—	—	—	—	—	—
27 " 28	19	6	Four	SA	"	c. SA	—	—	—	—	—	—	—	—
28 " 29	19	5	"	"	"	d. "	—	—	—	—	—	—	—	—
29 " 30	20	5	"	DA	"	c DA	—	—	—	—	—	—	—	—
30 " 31	20	5	"	"	"	c. "	—	—	—	—	—	—	—	—
31 " 32	—	—	—	—	—	—	—	—	—	—	—	—	—	—
32 " 33	—	—	—	—	—	—	—	—	—	—	—	—	—	—
33 " 34	—	—	—	—	—	—	—	—	—	—	—	—	—	—
34 " 35	—	—	—	—	—	—	—	—	—	—	—	—	—	—
35 " 36	—	—	—	—	—	—	—	—	—	—	—	—	—	—
36 " 37	—	—	—	—	—	—	—	—	—	—	—	—	—	—
37 " 38	—	—	—	—	—	—	—	—	—	—	—	—	—	—
38 " 39	—	—	—	—	—	—	—	—	—	—	—	—	—	—
39 " 40	—	—	—	—	—	—	—	—	—	—	—	—	—	—
							Two	16½ under 17½	17	7	Two	DA	—	DA
								17½ " 18½	18	7	"	"	—	"
								18½ " 19½	19	7	"	"	—	"
								19½ " 20½	19	7	Three	SA	DA	"
								20½ " 21½	19	6	"	DA	"	"
								21½ " 22½	20	6	"	"	"	"
								22½ " 23½	21	6	"	"	"	"
								23½ " 24½	22	5	"	"	"	"
								24½ " 25½	23	5	"	"	SHB+DFA	"
								25½ " 26½	24	5	"	"	"	"
							Three	9 " 20	24	6	Two	"	—	"
								1 " 21	24	6	"	"	—	"
								21 " 22	24	6	Three	SA	DA	"
								22 " 23	24	6	"	DA	"	"
								23 " 24	24	5	"	"	"	"
								24 " 25	25	5	"	"	"	"

SA=Single Angle; DA=Double Angles; SHB=Strong Hold Beams 10 frame spaces apart; SFA=Single Face Angle.
a. This column applies to both types of vessels.
b. A wide Stringer is to be worked in way of Strong Hold Beams.
c. An additional Plate Side Stringer of same construction at upper bilge.
d. An additional Plate Side Stringer with double face Angles at upper bilge.
e. Height between decks taken as 7 feet 6 inches.
Plus sign (+) means "with a."

2. The plate side stringers are to be worked intercostally between the frames with a single clip to the shell. Their thickness is to be the mean between that of the frames and the side plating. Their width is to be equal to the depth of the framing plus the width of the flange of the face angle bar.

3. If a single face bar is used on the inner edge of the side stringer its sectional area must equal that of the double keelson angles, with a broad enough flange to permit of two rivets to the reverse frames. When three or four face angles are called for the width of the side stringer plate must be such as to provide for riveting the broadest flange of said bars to said plate.

4. Bulb angles may be adopted in place of angle bars for face angles if of the same strength.

TABLE 5.—DECK FRAMING IN LIEU OF WEB FRAMES.

SINGLE DECK VESSELS						MULTIPLE DECK VESSELS						
a Molded Depth to Upper Deck Amidships; to Second Deck in Awning Deck Vessels	Depth of Framing Inches	b Intercostal Plate Side Stringers				No. of Deck Tiers	d Depth to Lowest Deck	Depth of Framing Inches	Intercostal Plate Side Stringers			
		Number	Face Angles Upper	Middle	Lower				Number	Face Angles Upper	Middle	Lower
Feet							Feet					
15 under 16	6	Two	SA	—	DA	—	—	—	—	—	—	—
16 " 17	6½	"	"	—	"	—	—	—	—	—	—	—
17 " 18	6½	"	DA	—	"	—	—	—	—	—	—	—
18 " 19	7	"	"	—	"	—	—	—	—	—	—	—
19 " 20	7½	"	"	—	"	—	—	—	—	—	—	—
20 " 21	7½	Three	"	DA	"	—	—	—	—	—	—	—
21 " 22	8	"	"	"	"	—	—	—	—	—	—	—
22 " 23	8½	"	"	QA	"	—	—	—	—	—	—	—
23 " 24	9	"	"	"	"	—	—	—	—	—	—	—
24 " 25	8	"	"	SHB+SFA	"	Two	16½ under 17½	7½	Two	DA	—	DA
25 " 26	8	"	"	"	"		17½ " 18½	8	"	"	—	"
26 " 27	8½	"	"	"	"		18½ " 19½	8½	"	"	—	"
27 " 28	8½	Four	"	"	c "		19½ " 20½	8½	Three	SA	DA	SA
28 " 29	9	"	"	"	c "		20½ " 21½	9	"	DA	"	DA
29 " 30	9½	"	"	"	c "		21½ " 22½	9½	"	"	"	"
30 " 31	10	"	"	"	c "		22½ " 23½	9½	"	"	QA	"
31 " 32	—	—	—	—	—		23½ " 24½	10	"	"	"	"
32 " 33	—	—	—	—	—		24½ " 25½	9	"	"	SHB+QA	"
33 " 34	—	—	—	—	—		25½ " 26½	9½	"	"	"	"
34 " 35	—	—	—	—	—	Three	19 " 20	9	Three	DA	QA	"
35 " 36	—	—	—	—	—		20 " 21	9½	"	"	"	"
36 " 37	—	—	—	—	—		21 " 22	9½	"	TA	"	"
37 " 38	—	—	—	—	—		22 " 23	10	"	"	"	TA
38 " 39	—	—	—	—	—		23 " 24	10½	"	QA	"	QA
39 " 40	—	—	—	—	—		24 " 25	10½	"	"	SHB+QA	"

SA=Single Angle; DA=Double Angles; TA=Triple Angles; QA=Quadruple Angles; SHB=Strong Hold Beams 10 frame spaces apart; SFA=Single Face Angle; Face angles to be riveted to reverse bars.
a. This column applies to both types of vessels.
b. A wide stringer to be worked in way of strong hold beams.
c. An additional intercostal plate side stringer of same construction at upper bilge.
d. Height between decks taken as 7 feet 6 inches.

ENGINEERING SPECIALTIES.

Composite Board.

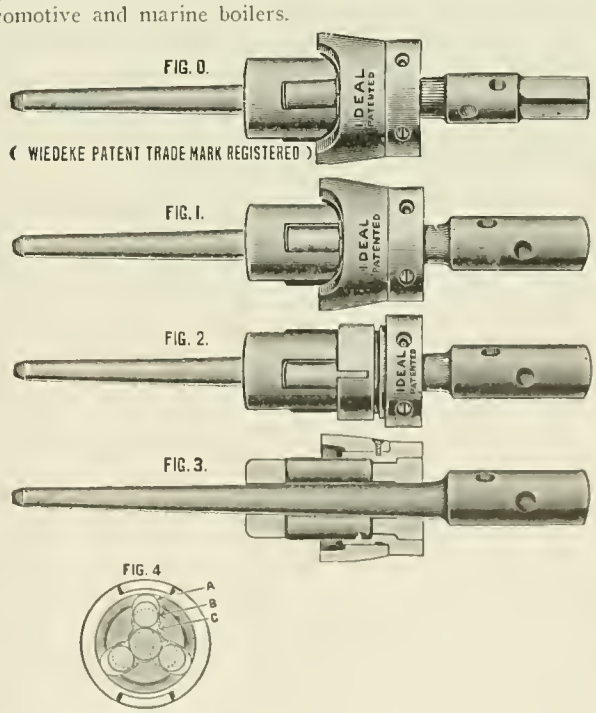
There has recently come into use among ship builders of this country an article which promises to supersede in a large degree wood panels on board steamers of all classes. We refer to "composite board," manufactured by the Composite Board Company, of 26 Cortlandt street, New York. This material being composed entirely of wood pulp, possesses all the advantages of wood itself, but having no grain, will neither warp nor split, and is impervious to moisture.

In its manufacture the wood pulp is reduced to a semi-liquid condition, and after the introduction of various chemicals, is formed in sheets ¼ inch thick and kiln dried. This process produces a hard flat board of uniform thickness, which, after further manipulation, is cut to desired dimensions, and the different sections are then glued under very heavy pressure, and allowed to dry thoroughly before finishing. By this process, the manufacturers are enabled to produce a finished board or panel of any thickness, 8 feet wide and 14 feet long, with perfectly smooth surface. The advantages of material of such dimensions for use in bulkheads, ceilings, and doors of steamers is at once apparent, not only on account of labor saving in fitting, but the advantage of having an unbroken, jointless surface. Besides flat sections for ceilings and panels, it is furnished curved to any radius, for use as casings to masts, or where circular sections are required.

Experiments prove composite board to be nearer sound proof than other materials, while as a non-conductor of electric current it is far superior to wood, sections ¼ inch thick having withstood upwards of 25,000 volts without piercing, and board ⅜ inch thick, more than 50,000 volts. The material is absolutely fire resisting, without the objectional features of so called fireproof wood. As it can be made of any desired thickness, it is also adapted for moldings of any section. Among the steamers equipped with composite board may be mentioned the *C. W. Morse*, now in service between New York and Albany, the Fall River Line steamer *Providence* and the *Merida* of the Cuban Mail Steamship Company. The accompanying cut shows its application on the *Providence*, the ceilings of large staterooms being made of a single piece, and all panels in the stateroom hall, as well as dome ceiling, being of the same material.

The Ideal Boiler-Tube Expander.

This expander, which is placed upon the market by Gustav Wiedeke & Company, of Dayton, Ohio, is said to be most simple and durable, with very great advantages as compared with many other types of roller tube expanders. The rolls are double the length of those in the ordinary expander, and are reversible which makes their life twice as long as in other cases. They can also be replaced with great facility, all that is necessary being the removal of the split cotter and of the cap in the rear, upon which the rolls will fall out automatically.

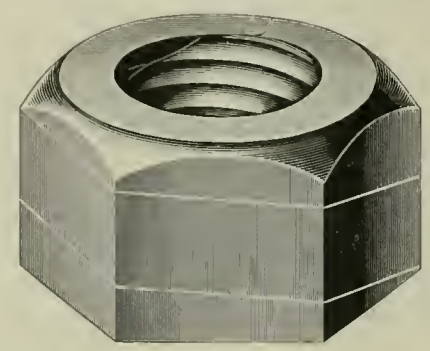


The roller frame is so constructed that the rolls cannot drop, even if the mandrel is removed, because of shoulders holding them in place. There are no cap screws to cause trouble, and the guard is readily removed when it is desired to work close to a boiler shell or rivet line, this being necessary in many

To use the Ideal tube expander, the rollers are set at the proper angle, and as soon as the mandrel is forced against them, it takes hold and gradually feeds its way in, thus producing a steady and even expansion of the tube and dispensing with hammering. The mandrel is so arranged that it can be used by hand power or by air drill power, whichever happens to be the better available for the case in hand.

The Helicoid Lock-nut.

This nut, which is placed upon the market by Bayliss, Jones & Bayliss, Limited, of 139 Cannon street, London, E. C., is made by coiling cold on a mandril a bar of steel of special section in such a manner as to form a close helical coil with a permanent set. This coil is then sawed into suitable lengths to correspond with the size of the nut, the blanks being then tapped, faced, shaped as required, chamfered and countersunk at both ends.



In tapping, the threads are cut to the same pitch as those of the bolt, but as the internal diameter of the nut is made slightly smaller than the diameter of the bolt, the nut necessarily expands on being put into place, and the spring of the coil is sufficient to hold it rigidly in position. This close gripping contact covers the entire length of the threads in the nut, and it is said that vibration will not shake it loose.

These nuts are made in seventeen sizes, to fit bolts from ¼ to 2 inches in diameter, and are tapped to Whitworth standard threads.

TECHNICAL PUBLICATIONS.

The Book of Boats. By Raymond Cavanagh, with drawings by E. P. Seidel. Size 5 by 6½ inches. Pages, 124; illustrations, 60. Chicago, Mahin Advertising Company. Price, in flexible covers, 50 cents.

Beginning with the earliest form of water craft, this little work comprises the history and development of the small boat, from the peculiar forms devised by savages in all lands and ages, to modern power boats of the latest type. Some of the constructions described are of the crudest and oddest description, and examples are taken from all over the world. The illustrations are pen and ink drawings, and cover with a good deal of completeness the various forms of boats described. Acknowledgment is made at the end to the Truscott Boat Manufacturing Company, for designs of the later type of boats.

Howell's Album of Marine Celebrities. By G. F. Howell. Size 6 by 9 inches. Pages 172. New York, 1906. The American Shipbuilder. Price, bound in flexible leather covering, $3.

This book consists of photographic reproductions and very brief notices of more than two hundred men prominent in the marine field in and around New York, as well as in other parts of the country. Most of the subjects of illustration are still active in their life work, although a few sketches are given covering men who have been prominent in the past, and have either been retired or have gone from our midst. The sketches are printed on one side only of the paper.

Morton Memorial; a history of the Stevens Institute of Technology; edited by Professor F. D. Furman, M. E. Size 8 by 11¼ inches. Pages 641. Numerous illustrations. Hoboken, 1905. Stevens Institute of Technology. Price $10.00.

This is a monumental volume begun by President Morton as a memorial at the twenty-fifth anniversary of the Institute, and completed after his death. It includes not only the history of the Institute, but gives also brief biographies of the trustees, faculty and alumni, and contains a record of the achievements of the Stevens family of engineers. The record of the Stevens family is one of exceeding interest to engineers generally, because of the great inventiveness shown by the various members of the family during the past century or more, and the importance of the interests which they served. It will be remembered that John Stevens operated a steamboat on the Hudson river three years before Fulton's *Clermont* made its appearance, and that the first armored war vessel ever started for the United States Navy was placed under construction by Robert L. Stevens in 1842. The steam railroad was another important item in connection with the engineering developments of John Stevens, in the early part of the 19th century, and a great variety of mechanical devices of all sorts may be traced to the enterprise of this remarkable series of men.

The book is splendidly printed upon an excellent quality of heavy paper, and is bound in leather.

Marine Boilers. By L. E. Bertin. Translated from the French by Leslie S. Robertson. Size 5¾ by 8¾ inches. Pages 658. Figures, over 300. New York, 1906. D. Van Nostrand Company. Price $5.00 net.

This work, which is a second edition, includes a preface by Sir William H. White, and a new chapter on liquid fuel by Engineer-Lieutenant H. C. Anstey, R. N. The subject is gone into with a great deal of thoroughness, and is well illustrated by cuts showing the different types of boilers, and their installation on board ship. A number of folding plates are included in the text, giving opportunity for the use of larger illustrations than would otherwise be the case. In addition to this are a number of plates on coated paper, with half tone illustrations of boilers of special types.

The subject of boilers for naval purposes is given a great deal of consideration, and much of the matter covers water tube boilers of various types. A great deal of detail is given regarding not only boiler construction and fittings, but also accessories, such as feed water regulators; various types of circulators and feed water purifiers; filters; oil extractors; feed water heaters; distillers; and even ash hoists.

At the end are given the reports of the boiler committee of the British Navy, dated from 1900 to 1904.

The subject of liquid fuel is taken up in considerable detail and well illustrated. Various furnace arrangements are shown, together with piping layouts, and details of burners for the use of oil. Calculations are given showing the determination of the size of openings and of the necessary quantity of air to be supplied for best results in combustion. Some attention is paid to mechanical stoking and to forced draft.

In the San Francisco catastrophe, the Main Street Iron Works were totally destroyed, together with all drawings, records, etc. International Marine Engineering is requested to ask manufacturers and others to forward copies of catalogues, and anything else of interest for reference, to the Main Street Iron Works, Alex. de Bretteville, Manager, at the temporary office, 1024 Francisco street, San Francisco, Calif.

QUERIES AND ANSWERS.

All reasonable questions concerning marine engineering received from and signed by subscribers will be answered by the Editor in this column. All communications must bear the name and address of the writer.

Q. 343.—I would like to know the horsepower of a non-condensing engine of the following dimensions: diameter of cylinder, 12 inches; stroke of engine, 24 inches; revolutions per minute, 110; cut-off, two-thirds stroke; boiler pressure, 80 pounds. The engine is double-acting. A. C. R.

A.—The computation of the horsepower of an engine from data as given can never be exact, but it presents very little difficulty if an approximate result only is required. There are some assumptions which will have to be made in this connection before anything can be done, among which are the back pressure on the engine and the amount of clearance in the cylinder. We have assumed that the back pressure is 5 pounds above the atmosphere, and that the clearance may be represented by 10 percent of the piston displacement. We have, in working out the result, neglected the effect of the piston rod in decreasing the available area on the crank side of the piston. We have assumed that the drop in pressure between boiler and engine will be 5 pounds.

The pressure at which the engine takes steam is 75 pounds per square inch, gauge, which would be represented by about 90 pounds absolute. The ratio of expansion is represented by the piston displacement including clearance, divided by the displacement to point of cut-off including clearance, which would be in this case 33/23 or 1.435. The mean pressure of the inlet and expansion line may be obtained from the regular formula $p_m = p_i \times \frac{1+\text{hyp. log. } r}{r}$ but an easier way would be to take it from tables in which these various quantities are used. These tables give the ratio between p_m and p_i as 95 percent. As p_i is 90 pounds absolute, p_m will be 85.5 pounds absolute, and the mean effective pressure will be the difference between this and the 20 pounds absolute represented by the back pressure on the engine. This gives 65.5 pounds.

The length of stroke is 2 feet; area of piston is 113 square inches; and number of strokes per minute is 220. Using these quantities in connection with the mean effective pressure in the formula $\frac{p\ l\ a\ n}{33{,}000}$ the result figures out as about 99 horsepower.

We have assumed the back pressure a little high in order to offset the probable fall in the admission line near point of cut-off.

Q. 344.—Kindly answer the following questions as fully as you can spare space:

1. Does the use of the compressed air in the expander cylinder of an Allen dense air machine operate to increase the thermal efficiency of the machine?
2. Would not the thermal efficiency be as great if the air was expanded directly into the cold air line? Why?
3. Why would not an expander cylinder be desirable on an ammonia or CO_2 machine? C. W. D.

A.—(1 & 2) The power which is stored in the compressed air must, during the coming to a lower pressure, exert itself on something and produce heat there. When the air is expanded slowly in an expander cylinder, the power is taken up outside of the body of air, and produces the heat there. In an air ice machine this power is utilized to help in compressing the air, by linking the expander to the compressor.

When the compressed air is blown out freely through an opening the inherent power is turned first into velocity of motion of the air, and this velocity of motion is at some point stopped by something and turned to heat there in the body of air, and during a continuous process of compression and blowing out refrigerates the air but very slightly.

(3) Theoretically one might figure an advantage by the use of an expander, under certain circumstances, in chemical ice machines, but practically the chemicals used in ice machines are chosen so that they, without the use of an expander, give temperatures as these are practically required, and the use of an expander would be an unnecessary complication H. B. R.

Q. 346.—In reading over the April number of your magazine I came across two or three words that I do not understand the meaning of, as follows:

(*a*) Page 129, first line at top of second column, "Midship section is 143.54 square feet, corresponding with a coefficient of 0.957." What is the meaning of "coefficient" in this case, and how is it figured out?

(*b*) What is block coefficient?

(*c*) On page 146, the writer gives the dimensions of the *Adventure*, length, 374 feet; beam, 38 feet 3 inches; molded depth, 23 feet 3 inches; draft, 12 feet 6 inches; displacement, 2,620 tons; coefficient of fineness, 0.51. What is the meaning of "coefficient of fineness," and how is it figured out?

(*d*) Second paragraph, second column, "plate 27 inches wide and 17 pounds thick." What is meant by "17 pounds thick?" J. W. C.

A.—(*a*) This vessel has a beam of 30 feet and draft of 5 feet, hence if the shape of midship section were a rectangle with above dimensions the area would be 150 square feet The actual area, however, as given above, is less than this, and the coefficient given shows the ratio between the actual area, and the area of the rectangle having dimensions equal to the extreme dimensions of the section. This coefficient thus shows the fining away of the section of the boat around the bilges

(*b*) The block coefficient is the ratio between the volume of water displaced by a vessel when floating at its normal draft and the volume of a rectangular solid the length,breadth and depth of which are equal respectively to the length, beam and draft of the vessel.

(*c*) The coefficient of fineness of the *Adventure* as given on page 146 is the block coefficient described above. It is found by dividing the displacement of the vessel in cubic feet by the product in cubic feet of the length, beam and draft. The displacement in cubic feet is the displacement in tons multiplied by 35, there being 35 cubic feet in one ton of sea water.

Coefficient of fineness is a general term covering all sorts of coefficients of this character. It might include midship section coefficient, as mentioned above, or cylindrical coefficient, sometimes known as prismatic coefficient, which is the relation between the displacement of the ship and the displacement of a solid of the same length, but of a uniform cross section equal to that of the midship section; or it might mean any one of a number of other coefficients connected with the geometrical properties of the ship. These coefficients were explained in an answer to a Query, published at page 480 of our issue for November, 1905.

(*d*) A plate 17 pounds thick is a plate of such thickness that one square foot of the material would weigh 17 pounds. With wrought iron, a plate of one square foot in area and one inch in thickness weighs 40 pounds, while with steel the weight is 40.8 pounds. The thickness of the plate in question is a little more than 3/8 inch, as a 3/8-inch plate would weigh 15.3 pounds per square foot.

Q. 347.—I notice that some papers speak of the speed of a ship as so many "knots," while others call it "knots per hour"; which is correct? N. S. Y.

A.—The knot is a measure of speed and not of distance, therefore, the speed of a ship should be expressed as being so many knots.

The distance, which is sometimes called a knot, but which is more properly known as a geographical or nautical mile, to distinguish it from the statute mile of 5,280 feet, is the length of a minute of arc on the great circle of a sphere whose area is that of the earth. It is slightly less than one minute of arc on the equator, and has been computed to be 6,080.27 feet. In practice the fraction is omitted, and 6,080 feet is taken as the length of a nautical mile.

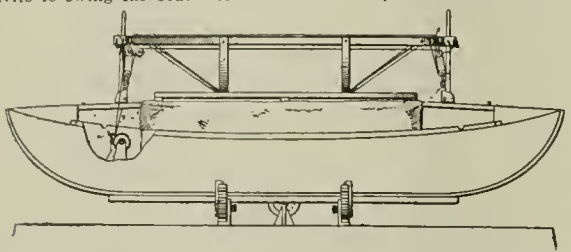
The term "knot" means really "nautical mile per hour," and hence the words "per hour" in the term "knots per hour" are wholly redundant.

SELECTED MARINE PATENTS.

The publication in this column of a patent specification does not necessarily imply editorial commendation.

812,069. ATTACHMENT FOR BOAT-DAVITS. NEIL MURCHISON, NEW YORK.

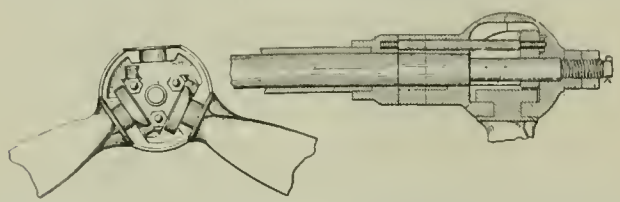
Claim.—3. The combination of a pair of connected davits each having a curved portion to support and overhang a boat, means for suspending one end of the boat from each of said curved portions, means for rocking the davits to swing the boat into and out of them, means for simultaneously



operating both of said suspending means, and additional means for lifting the boat out of the chocks of the davits; said last-named means comprising a lever fulcrumed to the suspending means and connected with the boat. Fifteen claims.

812,475. BOAT-PROPELLER. CHARLES E. BARBER, SYRACUSE, N. Y.

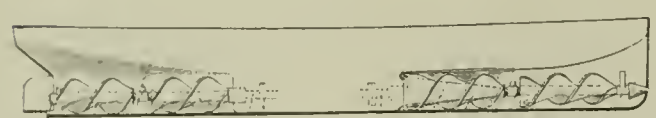
Claim.—1. In a boat-propeller, the combination of a rotary shaft suitably sustained against endwise movement, a propeller-wheel comprising a hollow hub mounted on said shaft and a plurality of radially-disposed blades pivotally and detachably secured to said hub, a block sliding



longitudinally on the shaft within the hub for turning the blades to either propelling or reversing positions, a longitudinally-shiftable sleeve embracing the shaft, means adjustably connecting the block to said sleeve and transmitting motion from the latter to said block, and means for shifting said sleeve. Five claims.

812,604. MARINE VESSEL. JOHN J. SITZLER, NEW YORK.

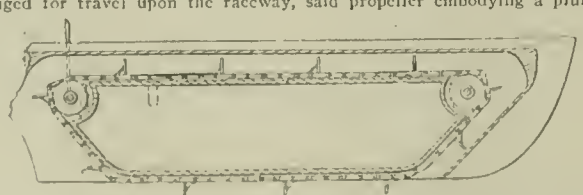
Claim.—1. A marine vessel having a hull with a pocket projecting downward from its bottom below the floor-line of the hull, said pocket being adapted to carry the engine crank-shaft, two propelling-screws projecting fore and aft and extending respectively from the ends of the pocket to the bow and stern, said screws having shafts projecting into the pocket and the shaft of the forward propeller being tapered from the pocket for-



ward, for the purpose specified, means in the pocket for connecting the shafts with the crankshaft, a conical head at the forward end of the forward screw and means for revolubly mounting the screws said means for mounting the screws comprising bearings at the bow and stern and an additional bearing for each shaft located intermediate the pocket and the bow and stern bearings respectively. Two claims.

813,648. ENDLESS PROPELLER FOR BOATS. GEORGE R. HORTON, SAN DIEGO, CAL., ASSIGNOR OF ONE-HALF TO EDGAR L. NICHOLSON, SEATTLE, WASH.

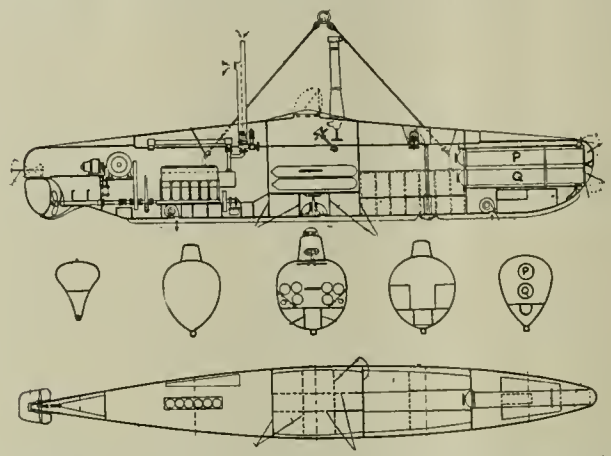
Claim.—1. In combination with a vessel, a raceway, an endless propeller arranged for travel upon the raceway, said propeller embodying a plurality



of chains, rollers mounted between the chains to reduce the friction between the chains and the raceway, and paddles carried by the chains aforesaid. Nine claims.

812,956. SUBMARINE VESSEL AND MECHANISM CONNECTED THEREWITH. GEORGE SIMPSON, MARINER HARBOR, N. Y.

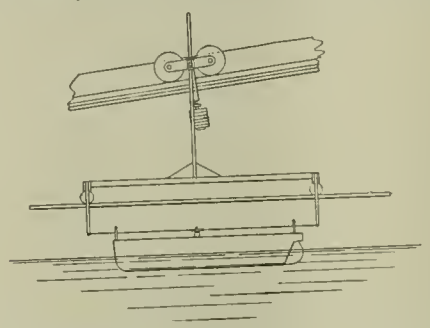
Claim.—2. A submarine having each of the following features; namely, vertical rudder and horizontal rudder, a hull devoid of external steering devices except said rudders and provided with an overhang above a rudder and propeller space, which hull is wider at both ends at the mid-height of said overhang than at the corresponding distance below the



center of gravity and is strengthened internally by transverse partitions and longitudinal partitions in the submerging water-tanks and externally by longitudinal plates forming an open-faced keel, sling-receiving devices of sufficient strength to support the submarine in air attached to said hull at about the level of said mid-height, a projecting spring-held bar between said keel-plates and an internally-located pump with vertical discharge for regulating the position of the submarine relatively to the plane of the horizon. Two claims.

813,413. EXPERIMENTAL TANK FOR TESTING SHIPS' MODELS. JOHN McLAREN FORD, BARROW-IN-FURNESS, ENGLAND.

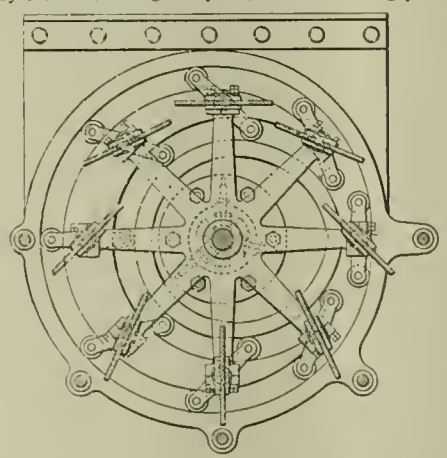
Claim.—3. An experimental tank comprising, in combination, a vessel,



an inclined railway supported on the vessel, a horizontal railway, a weighted trolley adapted to run on the inclined railway, a trolley adapted to run on the horizontal railway and means for connecting the trolleys together and to the model being experimented with. Six claims.

814,495. PADDLE-WHEEL. GUSTAF A. WIMAN, OF MALMO AND FRIDOLF SCHAUMAN, OF STOCKHOLM, SWEDEN.

Claim.—1. In paddle-wheels, stationary end plates, a shaft passing concentrically through said plates, each of said plates having a pair of slots disposed eccentrically around said shaft and so placed one within the other that they intersect at a given point, the intersecting point of the slots



in one end plate being at a phase difference of substantially ninety degrees from the intersecting point of the slots in the other end plate, paddle-boards interposed between said end plates, pivot members rigidly secured to each end of said paddle-boards, supporting-arms for said pivot members carried by said shaft, and rollers carried by said pivot members adapted to travel in said slots whereby the relation of the planes of the paddle-boards to the shaft will be constantly varied during the travel of the boards around said shaft. Two claims.

815,270. PROPULSION OF VESSELS. THADDEUS DAVIDS, LITTLE NECK, N. Y.

Abstract.—The invention consists in a vessel provided with a tube passing through the hull or extending from the bow to the stern of a vessel and with a propeller located directly at the end of the tube. Seven claims.

International Marine Engineering

JULY, 1906

THE NEW BATTLESHIP NEW JERSEY.

The official standardization speed trials of the *New Jersey* were held on March 28 and 29, 1906, on the Rockland, Maine, course. On March 28 the standardization trials were held, the fastest mile being made at the rate of 19.46 knots, and the average for the five highest runs was 19.02 knots. Fourteen runs were made in all, and the trial was so regularly conducted that the board was able to determine promptly that 124.5 revolutions of the screws would be necessary to give a speed of 19 knots. On the next day the four-hour endurance run was made in the open sea. The average revolutions of the screws for four hours were 126.297, giving a speed of 19.18 knots. The maximum speed for any fifteen-minute interval was 19.278 knots. The average horsepower developed in the main engines was 22,805, and the coal used showed a consumption of 2.22 pounds per indicated horsepower per hour. The usual tests in turning and backing were conducted after the four-hour run. There was no evidence during the trial of undue forcing of engines, boilers or auxiliaries.

A post trial examination of the machinery showed everything to be in perfect shape, and the board recommended the ship's acceptance without changes or repairs of any kind. The vessel returned to the yard of the builders, the Fore River Shipbuilding Company, Quincy, Mass., on March 29, and was delivered complete at the Boston navy yard on May 12—six weeks after the trial—which is an unusually short time.

BOW VIEW OF BATTLESHIP NEW JERSEY ON DAY OF FIRST COMMISSION, MAY 12, 1906.

The *New Jersey* is a first-class battleship of 14,948 tons, having a length on the water line of 435 feet, a beam of 76 feet 2½ inches, a draft of 23 feet 0 inches. The battery consists of four

12-inch and eight 8-inch breech loading rifles, twelve 6-inch rapid fire guns, twelve 14-pounders, twelve 3-pounders, eight 1-pounders, eight machine guns, two field guns and four 21-inch submerged torpedo tubes. The water line armor belt has a maximum thickness of 11 inches. Four of the 8-inch guns are mounted in two turrets superposed upon the 12-inch turrets, while the other four are in two separate turrets on the beams.

Propulsion is by twin screws operated by four cylinder triple expansion engines, having cylinder diameters 35, 57 and two of 66 inches, with a stroke of 48 inches. Steam is furnished by twelve Babcock & Wilcox boilers with an aggregate grate surface of 1,342 square feet and a heating surface of 56,184 square feet. The designed horsepower of 19,000 was considerably exceeded on trial. The coal supply under normal conditions is 900 tons, while a total supply of 1,700 tons is allowed for in the bunkers.

On completing the tests of the steering gear, the helm was put amidships, and after the vessel had gathered full headway on her course, the steam reversing gear of the main engines was reversed, the engines being started astern, and after they had begun to work astern for about three minutes were then again brought to full speed ahead.

After the fires had been sufficiently reduced to keep the steam pressure under control while the vessel was going astern at the rate of about 60 revolutions per minute of the main engines, the steering gear was further tested by working the helm through various angles up to the full angle of 35 degrees, port and starboard.

During the above tests of the steering gear, the general operation of the gear was satisfactory, and it should be noted that the quick working of the helm was readily obtained with one man at the steering wheel, showing the result of careful installation of transmitting gear from the bridge to the steering engine room.

The steam pressure allowed at the boilers was 278.25 pounds, and the board authorized the setting of the safety valves at 283.25 pounds; but the contractors decided to set the safety valves at about 278 pounds. The pressure allowed at the high pressure cylinders was 250 pounds. An average of 2 inches of water pressure in the fireroom was allowed, and was not exceeded. The coal used on the standardization trials was Pocahontas, "run of the mine," while that used on the four-hours' trial was Pocahontas "run of the mine" which had been shoveled over a sifter with about a 1½-inch mesh. This arrangement removed the fine coal, and the coal which was used was lumpy and excellent.

The following is a summary of the recorded observations in the log kept during the 4 hours' full power, maximum speed, forced-draft trial:

	Starboard	Port
Average revolutions per minute, four hours	126.274	126.320
Mean revolutions per minute, both engines	126.297	
Average steam pressure at boilers, in pounds	272	272
Average steam pressure at engines	244.2	246.2
Average air pressure in fireroom	1.84	1.84
Average vacuum	26.8	26.83

THE NEW BATTLESHIP NEW JERSEY AT SEA, STEAMING SLOWLY.

Collective indicated horsepower of both main engines	22805
Main engine, air, circulating, feed, and hotwell pumps	23089
Main and all auxiliary engines in operation during trial	23570
Average pounds of coal used per hour during trial	52300
Pounds of coal per hour used by main and all auxiliary engines in operation during trial	2.2214
Pounds of coal used per hour by main engines, air, circulating, feed, and hotwell pumps	2.26
Pounds of coal per hour per square foot of grate	30.02
Pounds per hour per square foot of heating surface	0.93
Displacement at mean draft at beginning of trial	14983 tons.
Speed of ship in knots	19.18
Admiralty coefficient of performance	190
Slip of propellers in percent of their own speed	17.25 17.16

LAUNCHING OF THE FRENCH ARMORED CRUISER ERNEST RENAN.

By J. Peltier.

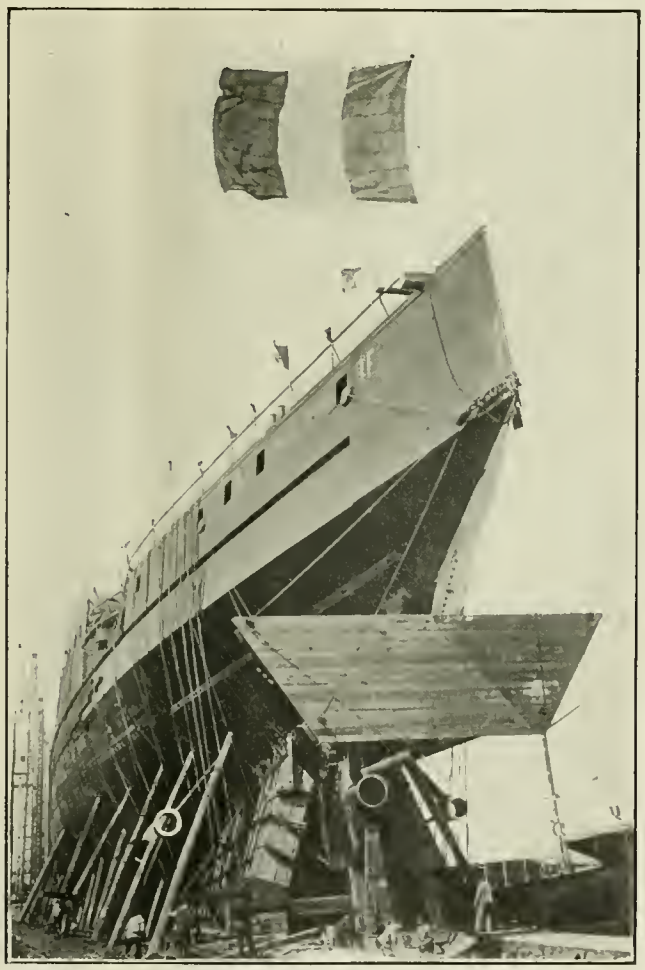
On April 9 this new armored cruiser, the largest and most powerful yet laid down in France, was launched from the yards of the Chantier et Ateliers de St-Nazaire, Penhoet.

The general dimensions and features of this cruiser are as follows:

Length on load water line,	157 m	515 ft. 1 in.
Breadth, extreme, at load water line,	21.31 m	70 ft. 1 in.
Gross draft, full load	8.18 m	25 ft. 10 in.
Displacement on trial	13,644 tonneaux	13,425 tons
Total bunker capacity, coal	2,300 "	2,263 "
Coal carried on trial	1,354 "	1,332 "
Trial speed at sea for three hours	23 knots	

HULL AND ARMOR

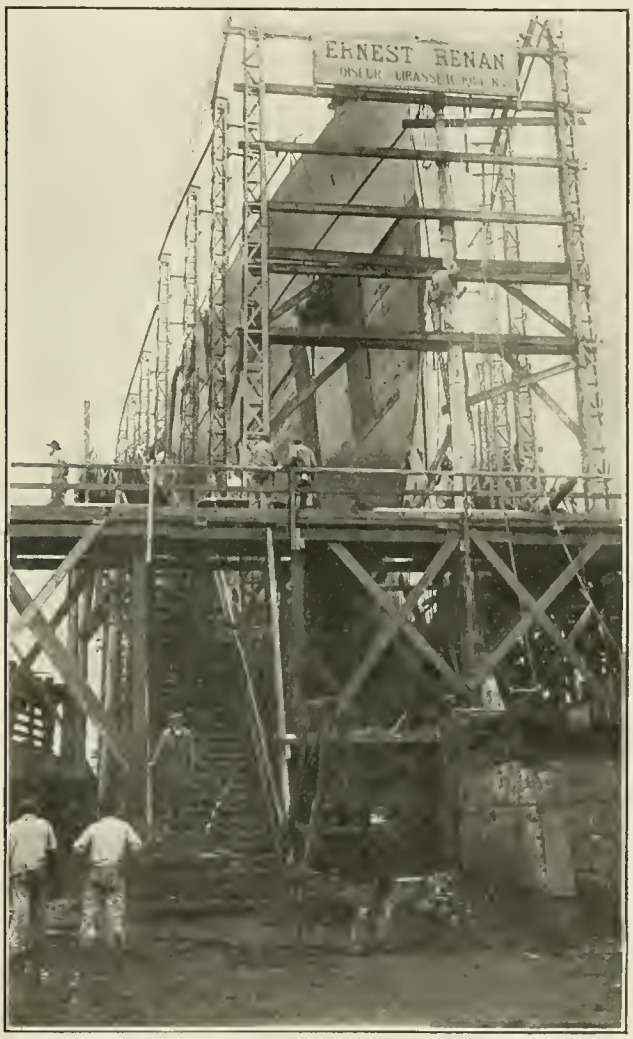
The hull is of steel throughout, fitted with docking and bilge keels. It is protected at the water line by a complete armor



STERN VIEW BEFORE LAUNCH, SHOWING THREE PROPELLER BRACKETS.

belt of 12 feet 3 inches in width, having a maximum thickness of 7 inches for about 295 feet amidships, the thickness being gradually decreased to 4 and 3 inches at the stem and stern. The two strakes of the belt side armor extend from 4 feet 8 inches below the water line to 7 feet 7 inches above the same, from the lower to the upper protective decks. The belt has its maximum thickness gradually reduced to the lower edge, where it is only 5 inches. The second strake is 5 inches thick amidships, and only 3 inches at the stem and stern. Astern, the belt side armor extends to only a few feet aft of the rudder, where an athwartship armor bulkhead extends to both sides, and from the lower to the upper protective deck. An armor strake extends from the stem to the forward casemates, reaching from the top of the water line belt to the lower edge of the gun deck, and is 2 inches in thickness.

There are two athwartship armor bulkheads extending from the shell plating at the ends of the casemates to the 7.7-inch barbettes, and 6 inches thick throughout. There are two protective decks extending from the stem to the stern; the lower deck being flat amidships, but sloped at the sides, and at each



BOW VIEW OF SHIP BEFORE LAUNCHING.

end it will be built with 1.5-inch plating throughout, with additional nickel steel of 1.8-inch on the slopes. The upper protective deck is flat, and will be built with double plating. The axis of the lower protective deck is about at the level of the load water line; at the side it is 4 feet 8 inches below it, at the level of the lower edge of the belt side armor.

The side protection is completed by a cofferdam extending from the upper protective deck level to the lower protective deck level, and worked from end to end of the vessel. Behind this cofferdam there is a watertight bulkhead worked from stem to stern; the space between the cofferdam and the watertight bulkhead is used in its upper part as a passage for repairing breaches in the cofferdam, and in its lower part as a water way for the water coming through the breaches. Teak backing is fitted behind all side armor. The space between the belt side armor, the watertight bulkhead and cofferdam, and the two protective decks has numerous compartments, either empty or packed with cellulose or other approved water-excluding

material, or more simply filled with coal, fresh water, etc. The ammunition passages, funnels, air pipes, etc., going through this space are protected with an annular cofferdam extending from the lower to the upper protective decks.

Above the upper protective deck is the gun deck, extending from stem to stern; above this is the spar deck, extending from the stem to the after turret. On the spar deck is a large bridge extending from the fore turret to the three-quarters length of the deck. The conning tower is on the bridge deck, between the forward turret and the foremast; the conning tower and shield will have a thickness of 8 inches. An armor tube 33 inches in diameter will extend from the base of the conning tower to the protective deck, and will be 5 inches thick throughout.

The engines will be three in number, four cylinder, triple expansion type, of a combined indicated horsepower of 36,600, each driving a propeller. The steam pressure will be 250 pounds per square inch. The diameters of the cylinders are respectively 50, 78, 83 and 83 inches; the stroke is 40 inches. Each engine will be located in a separate watertight compartment.

THE ERNEST RENAN AFLOAT, QUARTER BOW VIEW.

The following auxiliary machinery is to be supplied, in addition to that pertaining to the main engines: steering engine, windlass engine, ash hoist engines, forced draft blowers, evaporating plant with a total capacity of 3,600 gallons of fresh water a day, distilling apparatus capable of condensing 12,000 gallons per day. The vessel is to be heated by steam throughout.

THIS VIEW GIVES A GOOD IDEA OF THE PECULIAR FORM OF THE STERN.

MACHINERY.

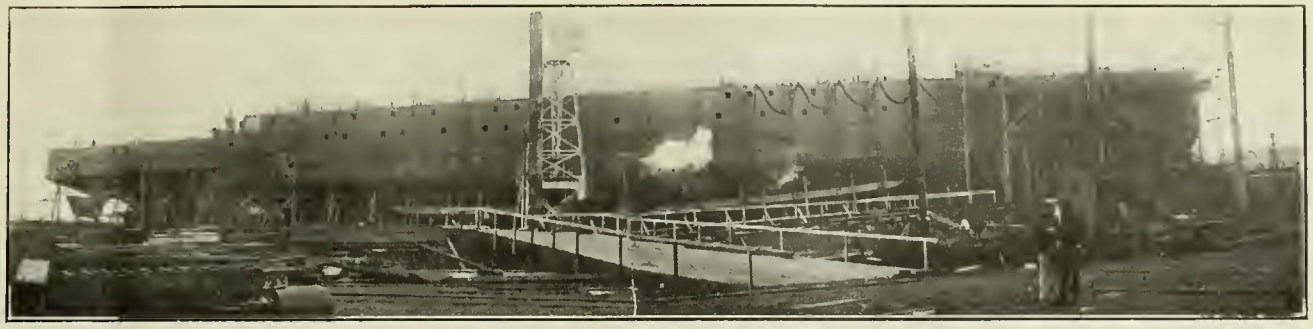
There will be forty-two boilers of the Niclausse type, placed in watertight compartments. They will have 2,680 square feet of grate and 94,580 square feet of heating surface, and will be able to furnish the steam for the main engines and all auxiliary machinery throughout the ship, with an average air pressure in the ash pits of not more than 1 inch of water. There will be six funnels, each 70 feet above the water line, and 20 feet in diameter.

The coal bunkers are arranged with satisfactory reference to the rapid and efficient supply of coal to the fire rooms, and have a maximum capacity of about 2,300 tons. With the ordinary supply of 1,354 tons the steaming radius will be, at 10 knots, 7,500 miles; and with 2,300 tons, 12,000 miles; at full speed the steaming radius is respectively 1,026 miles and 1,630 miles. A certain quantity of liquid fuel will be shipped in special tanks, and in the double bottom.

ARMAMENT.

Main battery: four 7.7-inch breech-loading rifles; twelve 6.4-inch breech-loading rapid fire guns. Secondary battery: twenty-four 3-pounder and 1-pounder rapid fire guns.

Two 7.7-inch guns and six 6.4-inch guns will fire right ahead or right astern, and four 7.7-inch guns and six 6.4-inch guns will fire on the broadside. There will be six 3-pounder guns on the gun deck, ten on the spar deck and eight on the bridges. There will be two 18-inch submerged torpedo tubes.



SIDE VIEW OF SHIP ON THE WAYS, SHOWING THE GREAT LENGTH.

The battery will be mounted as follows: the 7.7-inch guns in pairs in two electrically-controlled, balanced, elliptical turrets on the center line, one forward on the spar deck, the other aft on the gun deck. Eight of the 6.4-inch guns are in electrically-controlled, balanced, elliptical turrets on the spar deck, four on the port and four on the starboard side; two others are at each end of the superstructure.

The 7.7-inch barbettes extend from the protective deck to the spar deck for the forward barbette, and to the gun deck for the after barbette, and consist of 6.3-inch armor in front and 4.7-inch in the rear; the barbettes will not have any special framing, the

A VIEW OF THE PROPELLER APERTURE AND STERN.

connection of the armor with the decks being sufficient. The turrets will have a front plate 6.3 inches thick, rear plate 4.7 inches thick, and top plate 1.6 inches thick, with the upper tube 3 inches thick and lower tube of 1 inch thickness. The 6.4-inch barbettes will be 5.5 inches thick in front and 4 inches in the rear, with the upper tube 2.7 inches thick and the lower tube 0.8 inch thick; the turrets will have front plates 5.5 inches thick, rear plates 4 inches and top plates 1.6 inches thick.

The armor casemate extends from the top of the water line belt to the lower edge of the gun deck for the forward casemates, and is 5.5 inches in thickness; the athwartship bulkheads at the ends of these casemates extend from the shell plating to the 7.7-inch barbettes, and are 6 inches thick throughout. The casemate armor around the 6.4-inch guns on the gun deck is of nickel steel, the front plate is 5.5 inches in thickness, the splinter and inner plates are 2.4 inches thick, the floor and top plates are 1.2 inches thick. The casemate guns are arranged to fire dead ahead and astern respectively.

AMMUNITION.

Magazine bulkheads adjacent to heated compartments, such as fire rooms, engine rooms, dynamo rooms, etc., are arranged with air spaces. The shell rooms for the 7.7-inch guns are at the foot of the barbettes; the magazines and shell rooms for 6.4-inch and 3 pounder guns are between the main engine and fire room compartments, and they are so arranged that about one-half of the ammunition will be carried at each end of the ship.

The ammunition will be conveyed directly by hoist from the ammunition rooms or ammunition passages to the deck where it is required, or as near that as possible. The hoists will be driven by electric motors; for the transporting of ammunition, trolleys and tracks will be fitted in handling rooms, passages and shell rooms.

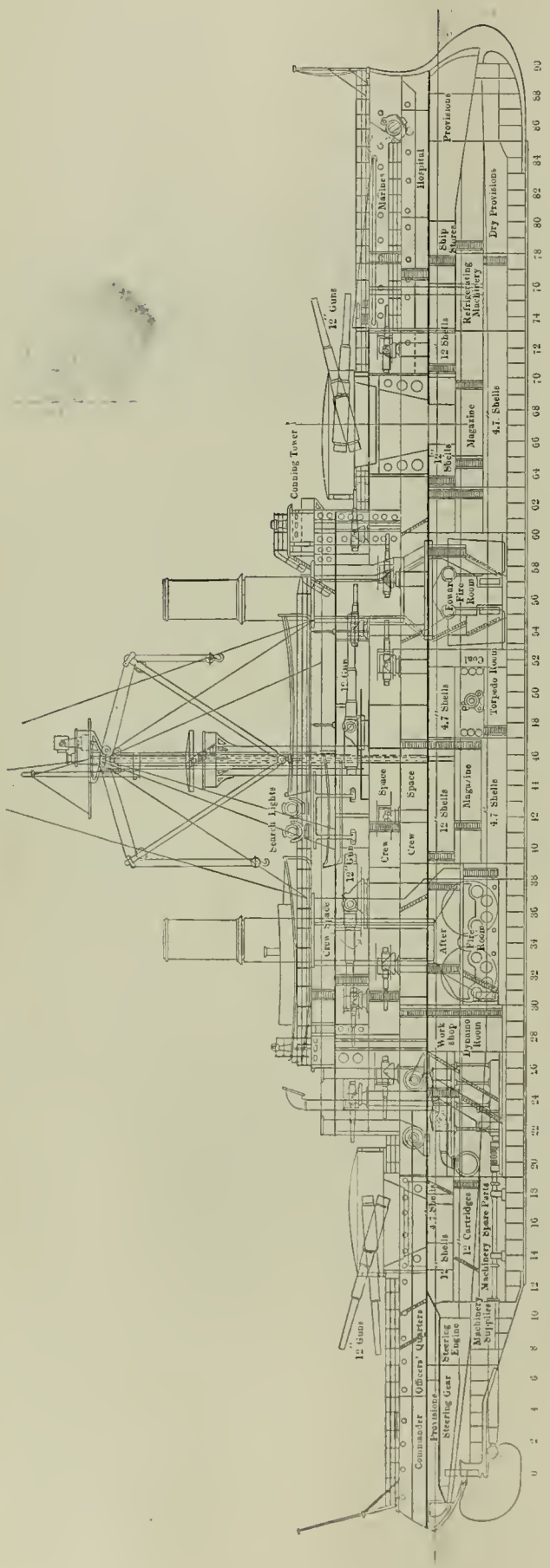
The keel of the cruiser was laid on October 21, 1903, the ship was launched on April 9, 1906, and she will be delivered to the navy in August, 1908.

NEW BATTLESHIP DESIGNS.

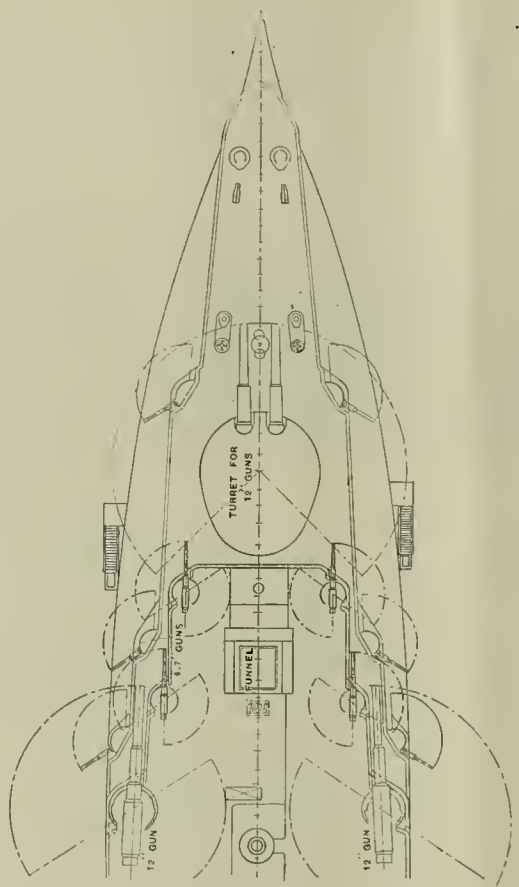
A POWERFUL RUSSIAN DESIGN.

Some months ago we were in receipt of two drawings covering a powerful battleship design which had been awarded a prize in a competition instituted by the Imperial Technical Society of St. Petersburg. The object of the competition was to develop a design suitable to the needs of the Russian navy, and this seems to have been accomplished on a very moderate displacement, but with so low a speed as to place the vessel rather in the class of a coast defender than in that of a high-sea battleship. On the question of gun power, however, there is little to be said against the design, particularly in view of the fact that the low displacement would enable a large number of the vessels to be built on the same expenditure of money as would be required for a much smaller number of larger ships. We are enabled to present herewith an inboard profile, together with two partial deck plans.

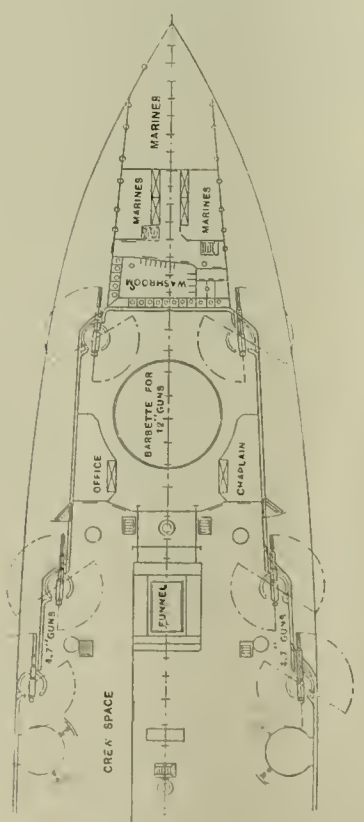
The design calls for a ship of 10,500 tons displacement, with a speed of 15 knots, the dimensions being as follows: Length over all, 112.5 meters (369 feet); length between perpendiculars, 108.5 meters (356 feet); beam, 21 meters (69 feet); draft, 6.8 meters (22.3 feet). The main battery consists of eight 12-inch guns, of which four are mounted in pairs in turrets forward and aft in the conventional manner, and the other four are mounted singly at the corners of an armored citadel, and at a slightly higher elevation than the after turret guns. The drawings indicate that the turrets can be trained through an angle of 132 degrees on each side of the center line, and that the other guns can be



INBOARD PROFILE OF IMPERIAL TECHNICAL SOCIETY'S PRIZE DESIGN FOR RUSSIAN BATTLESHIP.

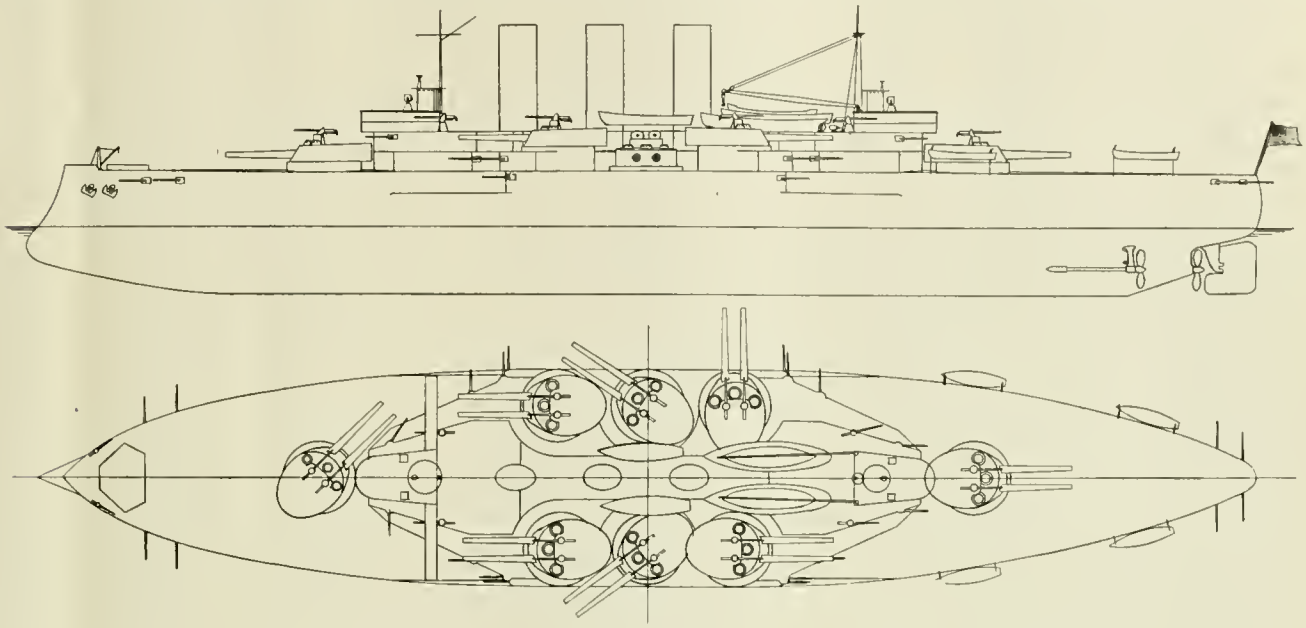


PLAN OF FORWARD PORTION OF MAIN DECK.

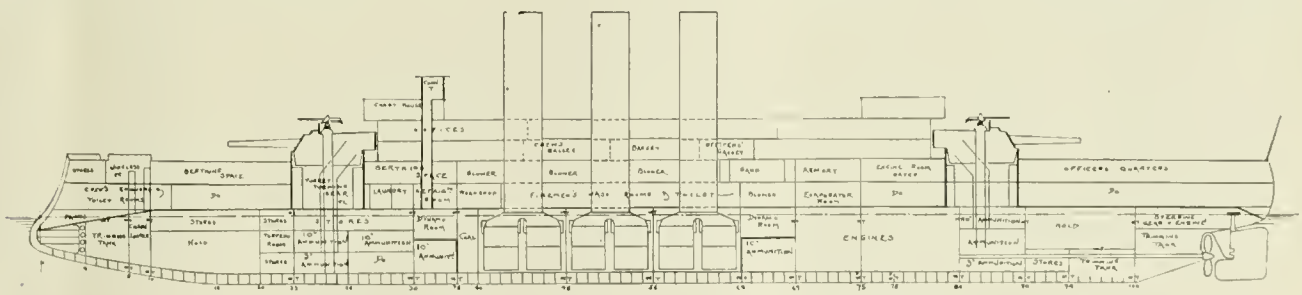


PLAN OF FORWARD PORTION OF BERTH DECK.

trained 2 degrees across the keel line and 35 degrees across the beam line, thus making an angle for each of 127 degrees. It is seen that the ship can bring to bear on a broadside six guns; forward or aft, four guns. The secondary battery, which is designed partly for the purpose of taking care of torpedo craft, and partly for attacking unarmored or lightly armored portions of other ships at relatively close range, consists of twenty 4.7-inch rapid fire guns, distributed on the main and upper decks. There are also two submerged torpedo tubes.



DESIGN X. OUTBOARD PROFILE AND WEATHER PLAN, SHOWING DISTRIBUTION OF BATTERY.

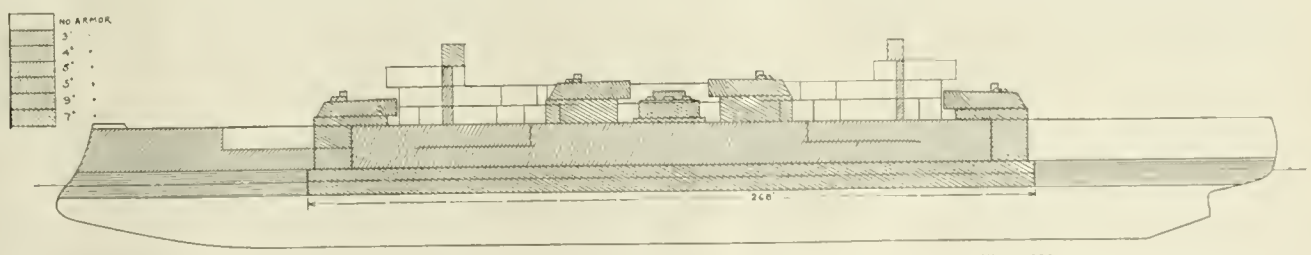


DESIGN X. INBOARD PROFILE, SHOWING GENERAL ARRANGEMENT.

AN AMERICAN PROJECT.

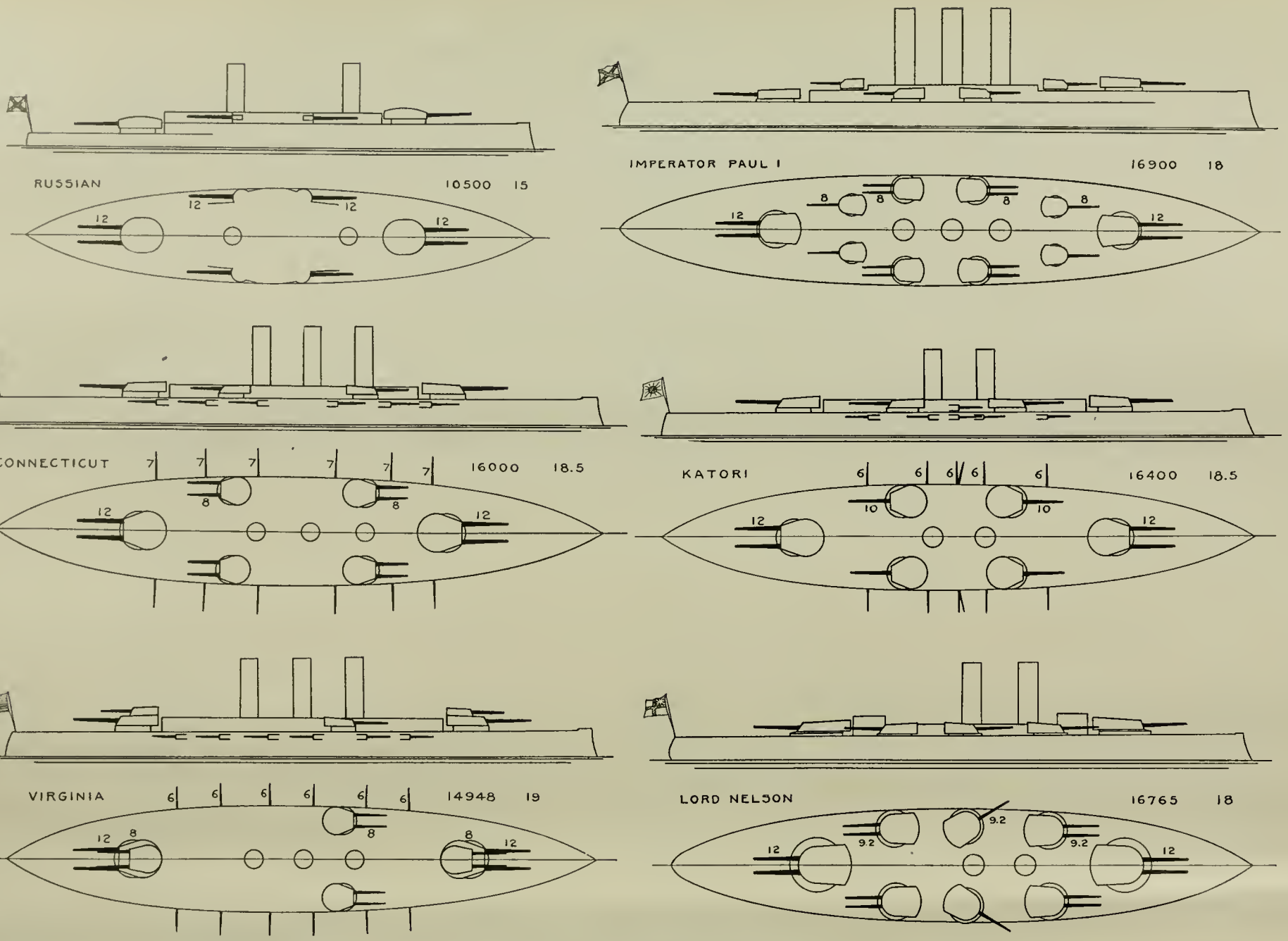
In this connection, a design was prepared some months ago by the Editor of this Journal, and submitted to the Navy Department, in which an attempt was made to provide on a displacement of 16,000 tons military qualities much superior to those in previous ships of the same displacement, and to provide a ship of sufficient power to successfully meet anything which might be brought against it, of either the same or a greater displacement. This somewhat ambitious project took the form of the use of heavy guns of great length, so placed as to bring to bear a large number at every point of the compass. This is here called "Design X."

The ship, as designed for a trial displacement of 16,000 tons, has a length of 450 feet on the water line, a beam of 80 feet and a uniform draft of 25 feet. This gives a block coefficient of 0.622, which is considerably less than that of other ships of this displacement now under construction for the United States Navy. The water line area figures out at 27,147 square feet, giving a water line coefficient of 0.754, and allowing for an added displacement of 64.6 tons for each added inch of immersion. The midship section area coefficient is 0.924, corresponding with an area of immersed midship section of 1,848 square feet. From the block coefficient and the midship section coefficient the prismatic or cylindrical coefficient is readily figured out to be 0.673.



DESIGN X. ARMOR PROFILE, SHOWING GENERAL DISTRIBUTION OF SIDE AND TURRET ARMOR.

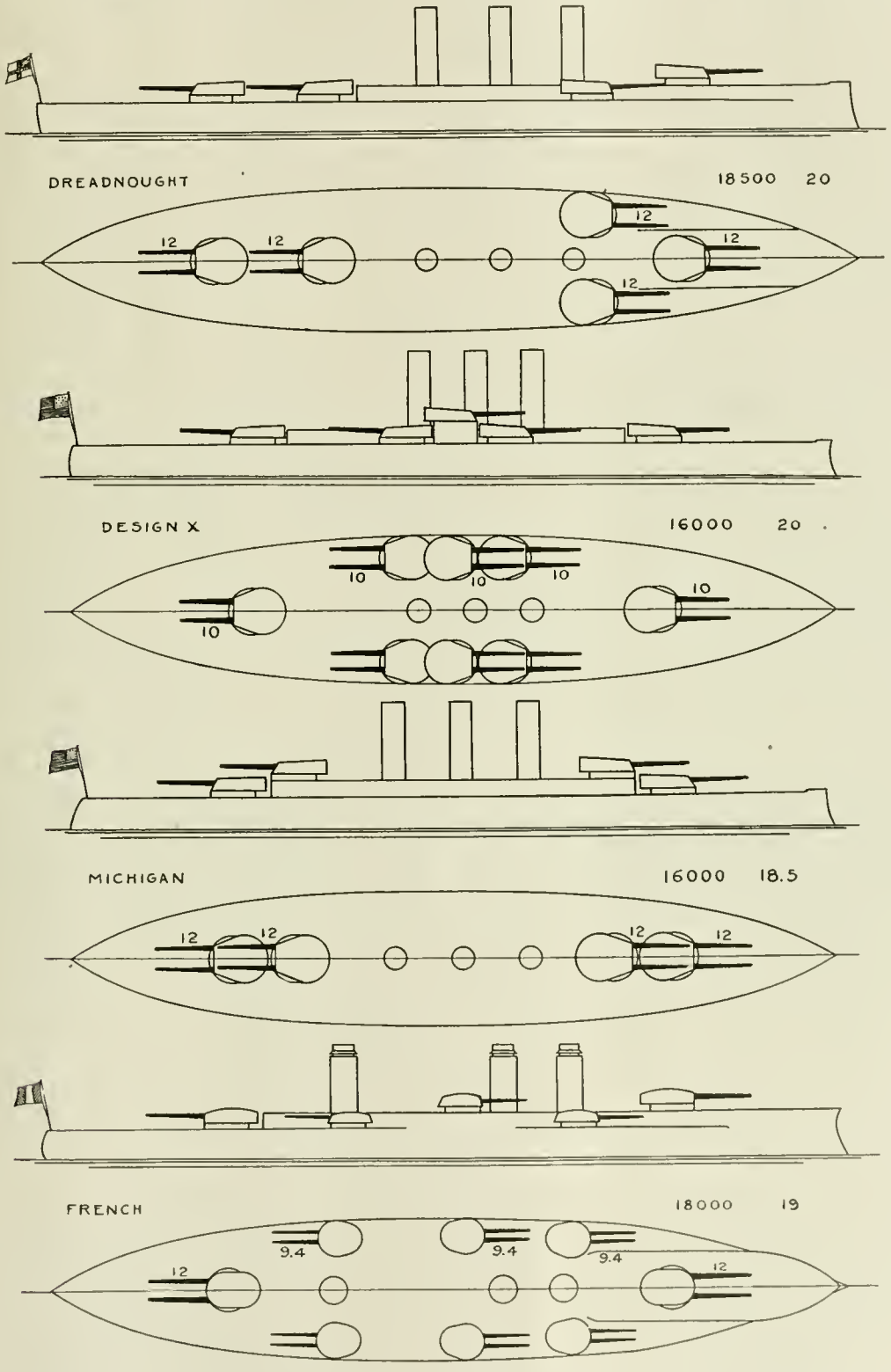
The machinery would consist of three sets of triple expansion or quadruple expansion engines, operating three screws, each having a diameter of about 15 feet and a pitch of about 20 feet, the number of revolutions being about 120 per minute. Steam turbines operating at a higher rate of speed, might be substituted. These



SKETCH DIAGRAMS ILLUSTRATING GUN DISTRIBUTIONS ON REPRESENGAGIVE BATTLESHIPS AND DESIGNS. SEE ALSO OPPOSITE PAGE.
(THESE DRAWINGS ARE ALL ON THE SAME SCALE, ABOUT 98 FEET TO THE INCH.)

engines would be furnished with steam by twelve boilers, and would be expected to develop a total of 21,000 horsepower, with a corresponding speed of ship of 20 knots. The Admiralty coefficient on this basis works out at 243, which, in consideration of the fineness of the lines, ought to be attained.

different positions, one shown in the large drawings of the ship, and the other in the smaller comparative drawing. Computations for gunfire are based on the latter. The elevation of gun axes above the mean plane of flotation is about 26 feet for 8 (twelve) of the guns, and 34 feet for the other 8 (four). The



The battery consists of 10 10-inch rifles, mounted in pairs in 8 turrets; 44 3-inch rapid fire guns, distributed in various positions on the ship; and two submerged torpedo tubes. The 10-inch guns have each a length of 50 calibers, and are mounted respectively in two turrets on the center line forward and aft and six turrets on the broadside. These latter were distributed in two

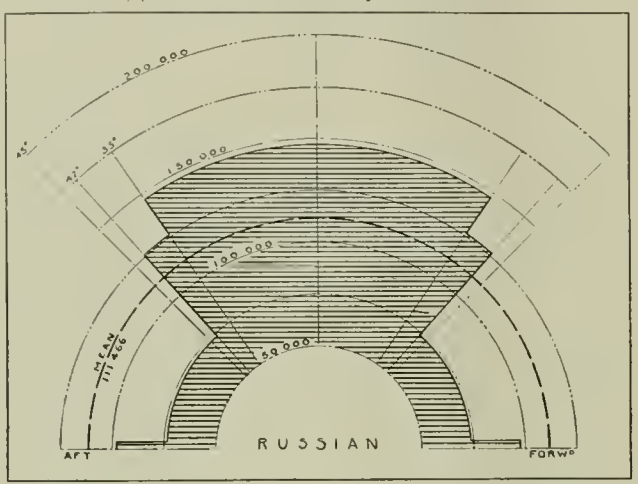
alternate design, which places the central turret on each broadside at the higher elevation, and the other broadside turrets at the lower, gives a larger range of fire for the broadside guns in general, but introduces the disadvantage of having some of these guns fire directly over the hoods of the others, when firing in line with the keel.

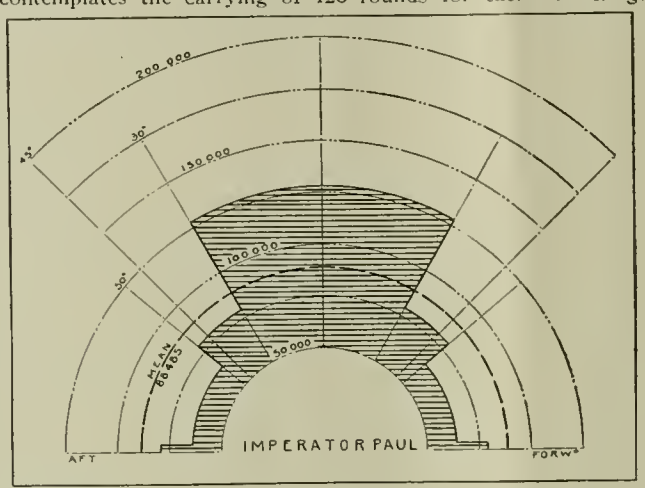
The protection includes an armor belt 9 inches thick and 9 feet 6 inches wide running for a length of 268 feet, which belt is tapered at the bottom to a thickness of 4 inches. Forward and aft of this belt, the water line protection is completed by 4 inches of armor. Above the main armor belt is a 6-inch belt of side armor extending for a distance of 240 feet, and measuring 14 feet 6 inches in width, thus reaching the upper deck. This protection is completed by means of 6-inch transverse armor running from the ends of the belt to the forward and aft turrets for 10-inch guns. The barbettes for the 10-inch guns, where exposed above side armor, have a thickness of 9 inches on the exposed half and 7 inches in the rear. The turrets for the heavy guns have 9 inches of armor in front, 7 inches on the sides and 5 inches in the rear. The complete protective deck has a thickness on flat of ¾ inch, and on the slopes of 2½ inches.

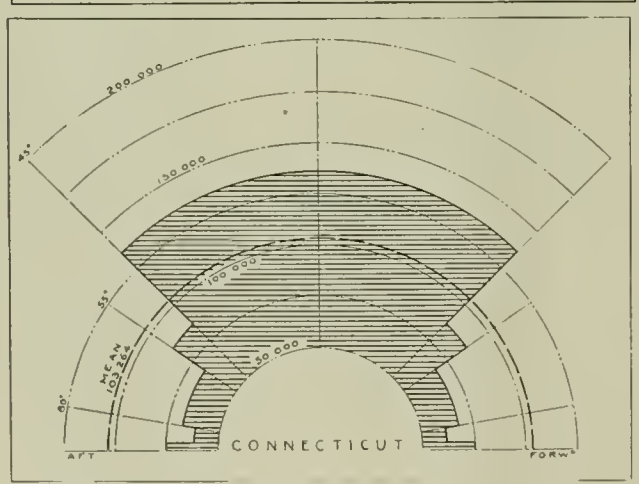
The weights of the various parts of the structure are given as follows:

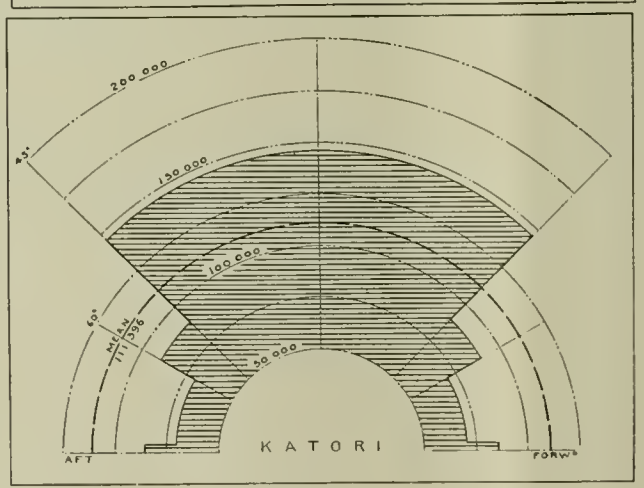
	Tons	*Percentage*
Hull and fittings,	6,000	37.5
Armor, complete,	4,000	25.0
Protective deck,	800	5.0
Equipment and stores,	600	3.75
Machinery, complete,	1,800	11.25
Coal supply,	1,000	6.25
Battery and ammunition,	1,800	11.25
Total,	16,000	100.00

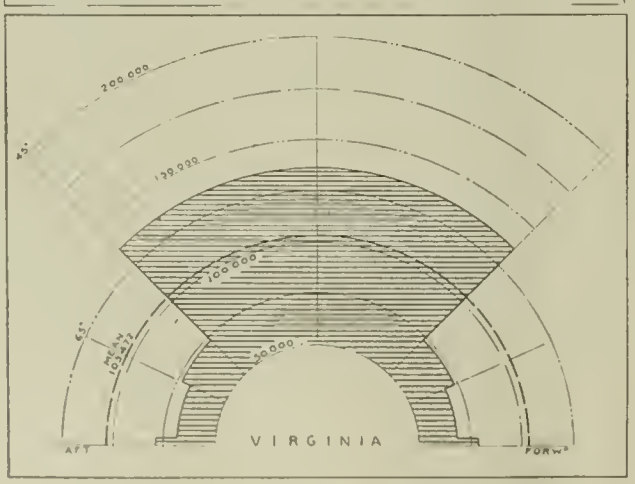
The provision made for the storage of coal allows for a total capacity amounting to 2,666 tons. The full ammunition supply contemplates the carrying of 120 rounds for each 10-inch gun,

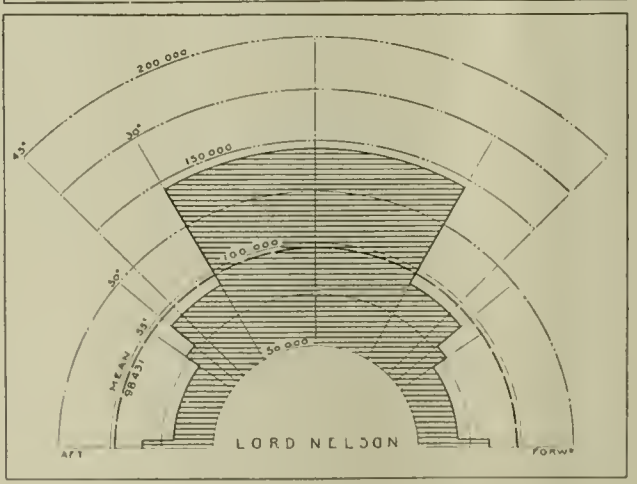








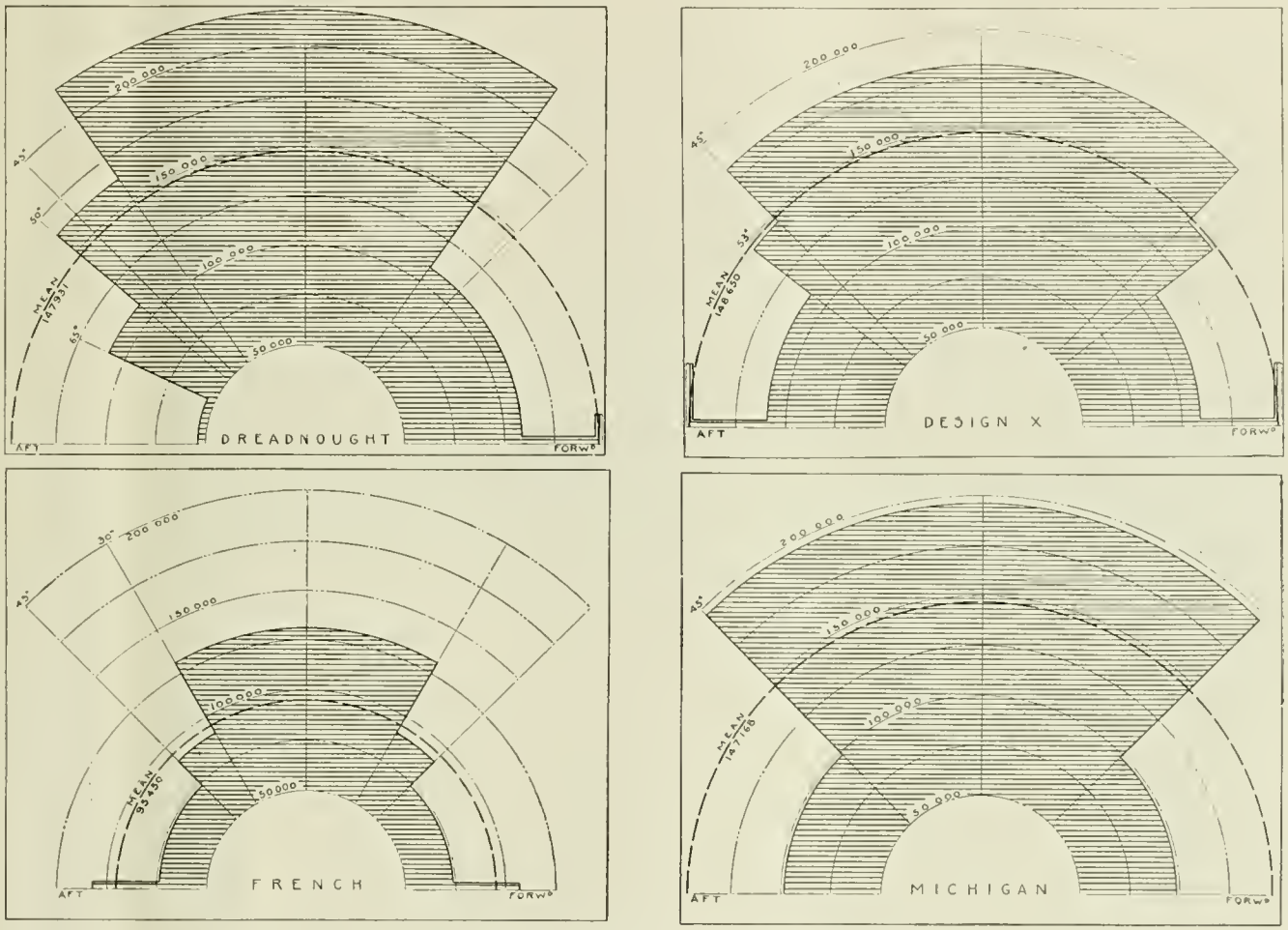




CHARTS SHOWING, BY SHADED AREAS, THE HORIZONTAL DISTRIBUTION OF GUNFIRE, IN FOOT-TONS, AT A RANGE OF 5,000 YARDS.

and 400 rounds for each 3-inch gun. Two-thirds of a full supply would, as in present United States navy practice, be carried at the trial displacement of 16,000 tons.

In fixing the armament of this ship it was decided to use heavy guns of a length of 50 calibers, for the reason that with this length extremely high muzzle velocities could be obtained, and, at the same time, a low trajectory, thus conducing to accurate firing. It is anticipated that with this length an initial velocity of 3,400 feet per second can be obtained. This would correspond to a muzzle energy of 40,000 foot tons, as compared with 27,200 for the present guns, and would provide an energy at a range of 5,000 yards of 18,202 foot tons, as compared with 24,528 foot tons for the present service 12-inch gun.



CHARTS SHOWING HORIZONTAL DISTRIBUTION OF GUNFIRE OF FOUR RECENT DESIGNS.

It was decided to use 10-inch guns in place of 12-inch guns, partly on the score of weight, and partly because of the fact that with 12-inch guns in turrets on either broadside so much of the beam of the ship would be taken up by requirements of the turrets that it would be necessary to provide a ship of very extreme beam in order to have anything left for the funnels and a passageway fore and aft. It is also believed that, although the "smashing power" and penetration of the 12-inch gun is greater than that of the 10-inch, yet the latter, when given a length of 50 calibers, will amply fulfil all reasonable requirements up to as great a range as human limitations will permit to be used in combat.

COMPARISONS.

In comparing these designs, so far as gun power is concerned, with those in other navies, and with other designs in our own navy, the comparison involves the energy at 5,000 yards of all guns of 6-inch caliber and upwards, it being assumed that smaller guns at that range would be valueless. (The 6-inch would be of very little account.) In these comparisons no account is taken of the greater rapidity of fire of the smaller sizes of guns, it being assumed that this advantage would be offset by the greater destructibility of the heavier shells, even aside from the greater energy which they would possess, and by the further advantage of the heavy shells' being able to puncture armor at this range which would be absolutely impervious to the lighter guns.

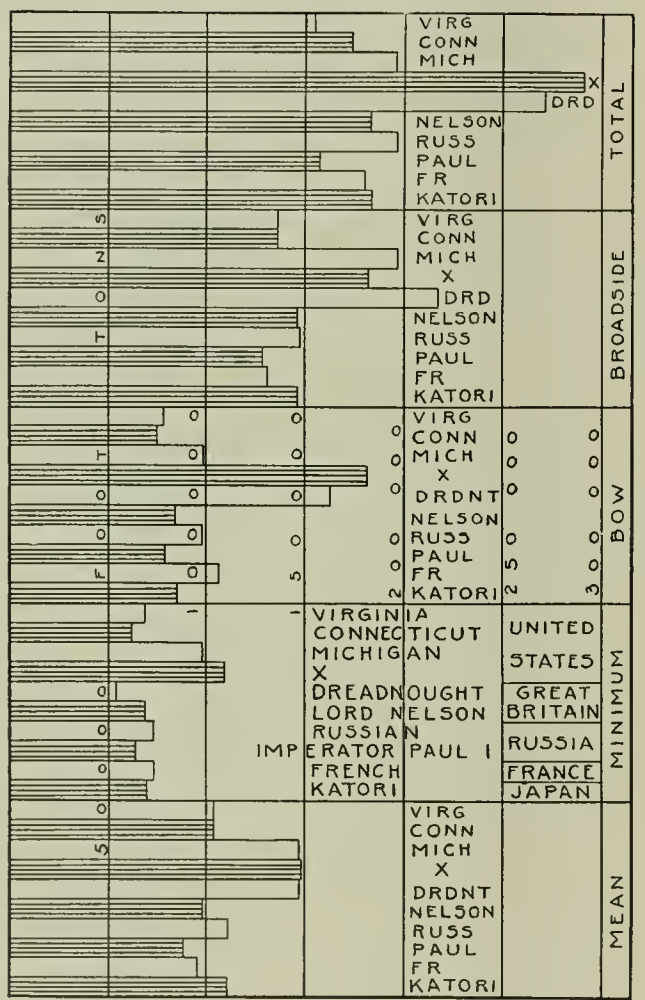
For the purpose of the comparison, data for the guns of the various ships are taken as follows:

United States		Velocity		Energy
Gun	Shot	Muzzle	5,000 yds.	5,000 yds.
12″	850	2,850	2,040	24,528
10″	500	3,400	2,291	18,202
8″	250	2,800	1,680	4,945
7″	165	2,000	1,614	2,981
6″	100	2,900	1,425	1,408
England				
12″	850	3,000	2,147	27,171
9.2″	330	3,000	1,808	7,481
Japan				
12″	850	3,000	2,147	27,171
10″	500	3,000	2,021	14,162
6″	100	3,000	1,474	1,507
Russia				
12″	850	2,850	2,040	24,528
8″	250	2,800	1,680	4,945
France				
12″	750	2,870	1,965	20,100
9.45″	375	2,870	1,704	8,370

Ten ships, in all, enter into the comparison. Their main features follow:

Ship	Displacement	Speed	Main Battery
Virginia	14,948	19	IV 12", VIII 8", XII 6"
Connecticut	16,000	18.5	IV 12", VIII 8", XII 7"
Michigan	16,000	18.5	VIII 12"
Design X	16,000	20	XVI 10"
Dreadnought	18,500	20	X 12"
Lord Nelson	16,765	18	IV 12", X 9.2"
Russian	10,500	15	VIII 12"
Emperor Paul I	16,900	18	IV 12", XII 8"
Voltaire	18,000	19	IV 12", XII 9.45"
Katori	16,400	18.5	IV 12", IV 10", XII 6"

On the basis of the data above given, the various ships com-



COMPARATIVE GUNFIRE SHOWING OF THE SEVERAL DESIGNS.

pared show energies of fire at 5,000 yards as recorded in the following table:

	Total	*Broadside*	*Bow*	*Minimum*	*Mean*
Virginia	154,568	136,230	78,726	68,836	103.472
Connecticut	173,444	135,778	74,798	61,927	103,264
Michigan	196,224	196,224	98,112	98,112	147,168
Design X	291,232	182,020	182,020	109,212	148,650
Dreadnought	271,710	217,368	163,026	54,342	147,931
Lord Nelson	183,494	146,089	84,266	69,304	98,431
Russian	196,224	147,168	98,112	73,584	111,466
Emperor Paul I	157,452	127,782	78,726	63,891	88,485
Voltaire	180,840	130,620	107,160	73,680	95,450
Katori	183,416	146,050	85,680	70,011	111,396

It will be noted that the maximum fire in any one direction is that possible to be obtained upon the broadside. The minimum fire is the least fire which can be obtained at any angle. The mean fire is obtained by dividing by 360 degrees, the summation of the products of the gun energies into the training ranges of the several guns, and represents the average fire which could be maintained around the horizon.

The design of the *Dreadnought* has been kept secret; the sketch and computations are based upon the best information at present obtainable. The same is true of the *Michigan*, and of the new French battleship, the latter design calling for a battery of four 12-inch and twelve 9.45-inch guns, distributed in accordance with the sketch diagram. It is said to be probable that there will be substituted for this battery one consisting of sixteen 9.45-inch guns; a new 10.6-inch gun is also under discussion. The design is by no means fixed. The other designs with which comparison is made are represented by diagrams showing distribution of guns, and no special mention of their features, other than that contained in the tables, is necessary.

It will be noticed that, with the single exception of the *Dreadnought*, the guns on these ships are balanced, as regards forward and aft fire, so that the angular distribution of energy in each of the four quadrants of the horizon, comprehended between lines parallel to the length of the ship and at right angles thereto, respectively, are symmetrical. In the case of the *Dreadnought*, however, the fire directly aft is only one-third of that directly forward, and the balance of fire between the line of the keel and an angle of 55 degrees from that line is very much disturbed. The total amount of the after section of the diagram is seen to be about equivalent to that of the forward, but its distribution is very different. These diagrams give a good relative idea as to the gun-fire possibilities of the several designs, for they are all drawn to the same scale, and each based upon the fire of all available guns of a caliber of six inches and upwards, at a range of five thousand yards, or slightly under three miles.

TRIAL TRIP OF ARMORED CRUISER WASHINGTON.

The *Washington*, which was built by the New York Shipbuilding Company of Camden, N. J., and was launched March 18, 1905, had a successful trial trip on the Rockland (Maine) course early in April of 1906. The standardization trial gave as a mean of five of the high speed runs 22.41 knots, the propellers turning at 124.99 revolutions per minute. A single run at 125.93 revolutions gave a speed of 23.29 knots. The ship was sent over the measured mile at varying rates of speed for fourteen runs, the object being the determination of the necesssary number of revolutions per minute for the attaining of the contract speed of 22 knots. This having been obtained, the ship was next day driven for four hours at such a speed that the propellers averaged 123.88 revolutions per minute, corresponding with 22.27 knots as the mean for the four hours.

The *Washington*, as described in our issue for May, 1905, on the occasion of her launching, is a twin screw armored cruiser with a displacement of 14,500 tons, and measures 502 feet on the water line, with a beam of 72 feet 10½ inches and a mean draft of 25 feet. The water plane area figures out at about 25,000 square feet, corresponding with an added displacement of 59.7 tons for each inch of additional immersion.

The battery consists of four 10-inch rifles in pairs in turrets forward and aft; sixteen 6-inch rapid fire guns on the broadside, of which four can be trained in the line of the keel in each direction; twenty-two 3-inch; twelve 3-pounder and four 1-pounder rapid fire guns; eight machine guns; two field guns and four 21-inch submerged torpedo tubes. Protection includes a water line belt measuring 5 inches thick amidships, and running the entire length of the ship. Barbettes for the 10-inch guns measure 7 inches in thickness on the exposed side and 4 inches in the rear; while the turrets have 9-inch port plates, 7-inch sides and are 5 inches thick in the rear. The protective deck at the ends of the ship has a thickness of 3 inches, while amidships the slopes are 4 inches thick and the flat portions 1½ inches.

Propulsion is by two four-cylinder triple expansion engines of a designed horsepower of 23,000. The cylinders measure 38½, 63½ and two of 74 inches in diameter, with a stroke of 48 inches. The engines are located in separate watertight compartments, and are supplied with steam by sixteen Babcock & Wilcox water tube boilers, with a total grate area of 1,600 square feet and heating surface of 68,000 square feet, the ratio being 43 to 1.

THE UNITED STATES ARMORED CRUISER WASHINGTON ON TRIAL TRIP.
Copyright, 1906, N. L. Stebbins, Boston.

COLD STORAGE ON BOARD SHIP.

PART I.

BY SYDNEY F. WALKER, M. I. E. E.

It is not much over thirty years since cold storage was first introduced, and not so long since the first cargo of dead mutton was first shipped, yet an enormous industry has since been built up in the transport of dead meat of all kinds, from countries such as the United States, Australia, New Zealand, and the Argentine, where it can be grown cheaply, to countries such as the British Islands and South Africa, where the conditions are not so favorable, and where consumption is large and increasing. The early cargoes of frozen meat were looked upon with great uneasiness in some quarters, and it is on record that the Duke of Beaufort once wrote to *The Times*, stating that it was flying in the face of Providence to use "such means to preserve produce which was never intended to be preserved in that way." In addition to this, a large fruit-carrying trade has grown up, increasing in dimensions every year, which enables those who reside in the northern hemisphere to enjoy the fruits that are being grown in the southern, at the time when their own fruits are not obtainable; the fruits that are transported being almost as luscious to the taste, after a journey of several thousand miles, as when picked on the spot. In fact, some of the fruits sold in London, that have been brought from Australia and Cape Colony, taste better than those grown in England itself.

There is another very useful office that cold storage has performed for those who go down to the sea in ships—it has enabled fresh meat to be carried for the whole of the voyage, quite apart from the live animals that can be stored; while the dead meat, properly preserved, is often better than that of the live animals carried, because it is not subject to sea-sickness and other ailments. Refrigeration also offers a means of dealing with the many problems in connection with the service of men-of-war, such as cooling the magazines, the men's quarters, etc.

Apart from the actual ability to freeze meat, and other produce that will stand freezing, and is preserved in that condition, modern cold storage apparatus enables the engineer to maintain any temperature that may be advantageous to the produce, and any degree of dryness, which is itself a most important point. Cold storage preserves by arresting the decay that would otherwise commence soon after the animal is killed, or the fruit is removed from the tree on which it grows. What we know as decay is really an organic chemical and bacterial action, and, as in all actions of the kind, heat plays a very important part in this. The presence of heat, up to a certain temperature, assists both the chemical and bacterial actions, while its absence retards them, hence the ability to preserve produce. But this it not the whole story.

Different substances demand different treatment in the matter of temperature for preservation. Mutton, lamb, rabbits, and some other meats or animals may be frozen as hard as you please, and if carefully thawed out when required for use are apparently little the worse; but beef, though it can be frozen, and if carefully thawed is quite eatable, does not command so high a price as if merely "chilled," that is, reduced to a temperature a little above the freezing point of the meat. Juicy fruits also must not be frozen, or they are naturally spoiled, from the fact that, the juices expanding in freezing, the other parts are injured. The fruit loses its vitality, its flavor. Eggs, vegetables and other substances also must not be frozen, for similar reasons.

Again, there is a great deal in the matter of the hygroscopic state of the atmosphere in which the produce is stored. If the air in the cold chambers carries moisture, it is likely to condense upon the produce, and that is bad from the viewpoint of preservation, as it assists any chemical actions that have commenced. There is also the question of the carriage of produce, such as apples and onions, with distinct odors of their own, which will be communicated to other produce if the air of the chambers in which the odorous produce is stored is allowed to penetrate to the chambers containing other produce. But all of this can be arranged, and quite simply, by modern refrigerating apparatus.

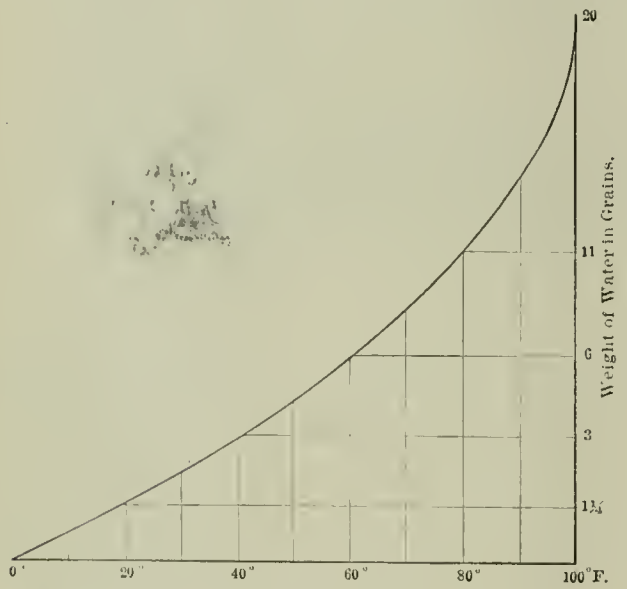
THE COLD STORAGE PROBLEM.

Stated briefly, the cold storage problem on board ship consists in the transportation of the heat present in the produce, and the heat which passes into the chamber in which the produce is stored, to the water of the sea, or to the atmosphere. Every

substance, whatever its temperature and whatever its composition, carries a certain number of heat units, depending upon its temperature and its specific heat.

A heat unit, or as it is usually written, a British Thermal Unit, which is one of the standards of heat employed in calculations, is the quantity of heat that will raise the temperature of one pound of pure water through one degree Fahrenheit, when at a temperature of 32 degrees F. The specific heat of any other substance is the ratio which the heat required to raise the temperature of one pound of the substance one degree F. bears to that required for one pound of water. The specific heat of water is taken as the unit, and, as that of the great majority of substances is less than that of water, their specific heats are usually expressed as fractions. The specific heat of every substance varies with the condition it is in. Ice, for instance, has a specific heat of only 0.4, as against 1.0 for water.

To reduce the temperature of any substance to freezing point, therefore, the number of heat units that have to be removed is found by multiplying the weight of the substance in pounds by the difference between the temperature at which the produce is received and that at which it freezes, and then by the specific heat of the substance. In addition to this, nearly all produce



CURVE SHOWING CAPACITY OF AIR PER CUBIC FOOT FOR HOLDING WATERY VAPOR.

that is to be stored in cold chambers consists partly of liquids, and when these are reduced to the solid form, the latent heat of the liquid has to be removed before it will freeze. With ice, for instance, the latent heat of water as a liquid has to be removed; this amounts to 142 units per pound. There is usually a still further quantity of heat to be removed, for it may be necessary to hold the frozen masses a few degrees below freezing point, so that in case the refrigerating apparatus does not work well, or if from other causes the temperature to which the substance is exposed is raised, it will not immediately thaw. Ice that is required for domestic or industrial purposes is reduced to a certain number of degrees below freezing point, in the process. Nature does exactly the same in the production of natural ice.

There is one other point. The freezing point of a liquid containing other substances in solution is lower than that of the liquid itself. Thus while the freezing point of water is 32 degrees F., that of milk, and of the blood and other liquids contained in the carcasses of animals, and that of the juices of fruits, is lower than that of pure water. Hence with such a substance as mutton, whose specific heat is 0.69 when unfrozen, and 0.38 when frozen, and the latent heat of whose liquids is 88 units, and which is held at from 16 to 25 degrees F., the number of heat units to be extracted will be found by first multiplying the weight of the liquids in the sheep in pounds (about 62 percent of the total weight) by 88, adding to this the product of the total weight multiplied by 0.69 and by the difference between the temperature at which the meat will be received and its freezing point, and adding to this again the product of the weight multiplied by 0.38, and by the difference between the temperature at which the meat is to be held and its freezing point.

Meat is always allowed to cool to a certain extent before taking into store. As cold store men and butchers express it, the animal heat is allowed to go off, this giving the refrigerating machinery so much less to do. Where the meat is beef, and is only to be chilled, the number of heat units to be taken out is much less than where it is actually frozen, as there is no latent heat to be taken account of, and the temperature has to be lowered only to about 33 or 35 degrees. In this case the quantity of heat units would be found by multiplying the weight of the meat by 0.69, and by the difference in temperature between 33 or 35 and that at which it was received.

This is the first part of the problem. The second part of the problem is that of the cold store itself.

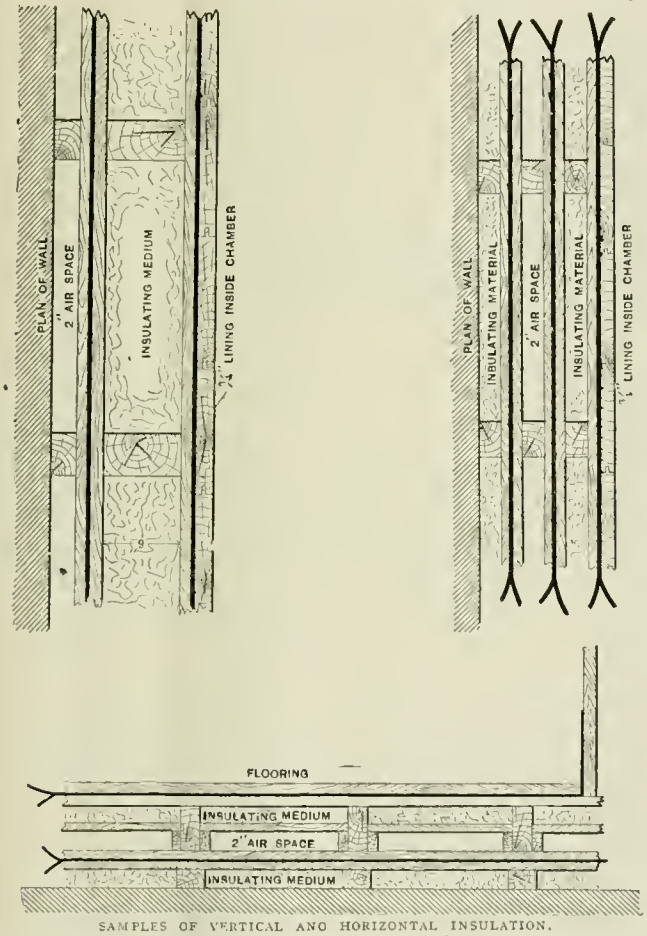
A cold store is a chamber that is built expressly to prevent heat from passing from outside to the produce inside. It is not possible to construct a chamber that will not allow some heat to pass through the walls, floor and ceiling, and this heat which is constantly leaking through into the chamber has to be removed, just as that of the produce itself is, and transported to the sea or the atmosphere. The quantity of heat that leaks through depends upon the difference of temperature between the inside and outside of the cold chamber, upon the construction of the walls, floor and roof, and upon the extent of the surfaces exposed to the action of the heat. Certain substances are good thermal insulators, just as certain substances are good electrical insulators, and the thermal insulators are used to prevent the ingress of heat into the cold chambers, in the same way that electrical insulators are used to prevent the egress of electricity from the conductors. This fact is very often not understood, and is sometimes challenged, because the sizes are so different; but if it be borne in mind that the thickness of the walls of the chamber correspond with the thickness of the insulating envelope of a cable, or even of the insulation of the iron core of the armature of a dynamo machine, though they are much greater, while the air inside the chamber corresponds with the copper or the iron, it will probably be appreciated that heat leaks in through the thermal insulator just as electricity leaks out through the electrical insulator.

Dry, still air is the best insulator known, and the other substances that are good insulators owe their property very largely to the fact that they contain a large number of very small air cells, across which the heat current has to pass. Air in motion is a bad insulator. If the air which is confined in the walls of the cold chamber is able to move, and to set up convection currents, it will by their aid transfer heat from outside to inside. Moisture also is a bad insulator, and if present will very considerably lower the degree of insulation.

The importance of good insulation can hardly be exaggerated. It is quite possible, if the insulation is sufficiently bad, that the refrigerating machinery may be grinding away uselessly the whole time, because the heat will be passing into the chamber as fast as it is being taken out. This may be seen from the following example: Peclet, an able French *savant*, gives the rate of transmission of heat through one inch of powdered wood charcoal, one of the substances used in cold storage work, as 0.63 units per square foot per degree F. per hour. Take a chamber cubical in form, 12 feet long on the side, giving a surface exposed to the heat of 864 square feet, and assume a difference of temperature of 50 degrees F. This would give a passage of 27,216 heat units through the walls, roof and floor on Peclet's figures, per hour, and would require approximately a 2-ton machine to handle comfortably. (The measurement of refrigerating machines, 1-ton, 2-tons, etc., will be explained later.) If we have, instead of one inch of the substance, six inches, as is far more common, the

rate of transfer of heat through the walls will be approximately one-sixth that with the one-inch, and a machine designed for a half ton should easily deal with it. On the other hand, if the insulation is so reduced that the rate of transmission through it is (say) 100,000 units per hour, in a room of that size, the whole power of a machine designed for six tons would be required.

Cold stores for ship work, and for a good many other places, are built up as follows: The space to be occupied by the cold chamber is surrounded by a double wall, which should extend to the decks, both above and below, both walls being formed of wood. Where it can be arranged, and where it is strong enough to stand the strains that are brought against the walls, they are built of matched boarding, securely nailed to uprights, the two sets of uprights being braced together and lined on the insides (the sides facing each other), and covered with waterproof paper.



SAMPLES OF VERTICAL AND HORIZONTAL INSULATION.
(Black lines show waterproof insulating paper.)

There are several papers made, consisting of tough manilla or other substances, saturated with substances impervious to water and to the rays of the sun, and these are used to line the space in which the insulating material is to be placed. Between the two walls, it will be understood, there is a space, broken up to a certain extent by the supports of the walls themselves, and into this space the insulating substance is poured and tightly packed. It is of great importance that the substance shall be so stowed that it cannot settle, or move in any way. The division of the space by the supporting timbers assists in this. If the insulation settles, leaving a space at the top, convection air currents are set up, which lower the insulation, and moisture may also get in.

The best insulating materials are silicate cotton, cork and finely divided charcoal. Silicate cotton, or slag wool, as it is often called, is a substance made from the slag of iron smelting furnaces. It is very largely composed of silicon, and in its preparation the slag is remelted in a small furnace, to which an air blast is attached which blows the molten slag into fine hair-like threads, or wool, something similar to spun glass. In this condition it is full of small air cells, and when packed tight, and moisture excluded, it makes the best insulator known. Finely divided wood charcoal is prepared in the process of wood distillation. The wood that is employed very largely, in the United Kingdom, is the waste cuttings from the willow used in the manufacture of cotton reels. It owes its property of insulation very largely to the air cells before mentioned. It should be packed tight, and dry. Cork in a finely divided state is another good insulating substance. Cork is an external growth on particular kinds of oak, which grow in certain parts of Spain, America, and a few other countries. It contains a number of very fine cells with thin walls, all built up together, very much as a honey comb is built up, but with the walls very much thinner and the spaces much smaller. It is used in a finely divided or broken up state, as the other materials are, and also in the form of cork bricks, which can be worked into any position required. The bricks have the air cells, just as the small pieces of cork have, the latter having in addition the air spaces between the pieces. Cork bricks have the advantage that they enable a much better mechanical job to be made. With a ship

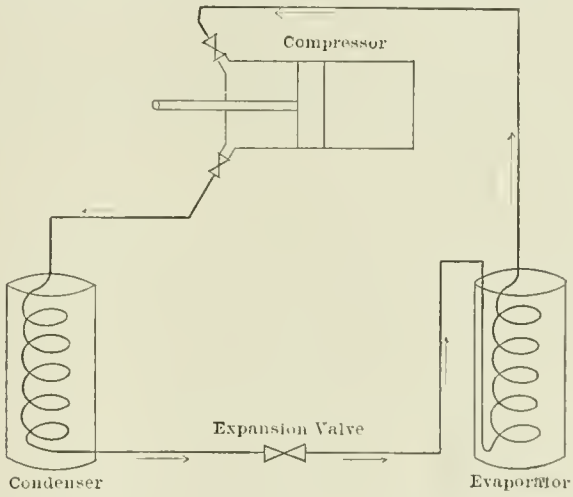


DIAGRAM OF COMPRESSOR CIRCUIT, WITH CONDENSER AND EVAPORATOR.

knocking about in a sea way, this is a matter of considerable importance, as, if the walls are sprung and air admitted, the insulation may be practically destroyed.

There are a number of other substances that are available as insulators. The problem, it will be understood, is very similar to that of insulating steam pipes, the same materials being used for the two purposes, where they can be. In the one case the object is to prevent heat of the steam inside the pipes from leaking out, while in the other the object is to prevent heat from outside from passing inwards. There is one important difference that should be noted, however. With high temperatures, still dry air is the insulator *par excellence*, especially where it can be applied in small quantities, as in the jackets of heating apparatus; but with cold storage apparatus air has not always such a good name, though it is acknowledged to be the best insulator; the reason being, the writer believes, that it is sometimes difficult to avoid convection currents. Another insulator is sawdust, which has been used a great deal on shore. It is a good and cheap insulator if applied quite dry and well shaken down. These two points are essential, and they are sometimes difficult to insure in sawdust. Other substances are asbestos and magnesia fiber, peat, ashes, fossil meal and finely divided mica. Felt, cow hair, infusorial earth, cotton wool, sheep's wool—all are used, to a certain extent, but silicate cotton, charcoal and cork are the principal ones.

In constructing the cold chambers on board ship, the outside skin of the insulating wall should be kept away from the ship's

side, and from any bulkhead that is in metallic connection with the ship, the engine room, or stoke hold. As far as it is possible, keep the cold chamber with a layer of air around it, but arrange if possible that this air be perfectly still and perfectly dry. The more nearly this can be attained, the lower will be the cost of running the apparatus. The case is exactly similar to that of electricity and to that of steam, though the direction of motion of energy has to be reversed. If steam or electricity are allowed to leak *out*, more coal has to be consumed to make up

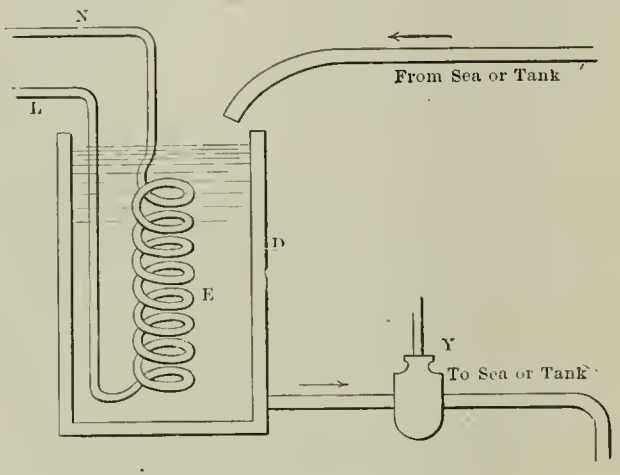


DIAGRAM SHOWING COOLING WATER CIRCUIT.

D, E.—Condenser and Coils. *L.*—Refrigerant Inlet. *N.*—Refrigerant Outlet. *Y.*—Water Circulating Pump.

the loss, and the accessories are more heavily worked. If heat is allowed to leak *into* the cold chambers, more coal has to be consumed in carrying it away, and there is also more work on the accessories. It is a good plan, when the mechanical conditions will allow it, to divide the insulating wall into two portions; the outer portion being simply an air jacket, and the inner portion carrying the insulating substance. Both should be lined with waterproof paper. In small cold stores, air jackets are often used alone with a waterproof paper.

It was stated above that the requirements as to temperature varied very considerably with the kind of produce carried, and it follows, therefore, that the construction of the cold chambers will vary though the main lines will be the same. For the large quantities of frozen sheep for instance, that are carried from New Zealand to the London docks—cargoes of 100,000 to 120,000 carcasses being carried—the bulk of the fore and after holds are converted into huge cold chambers, much as the holds are in petroleum tank steamers, except that there is no attempt at division of the holds for meat carriage. Probably the carriage of frozen mutton, with the few crates of frozen rabbits which are taken to fill up, represent the simplest case of cold storage transport. Freezing hard is the order, and as long as this is carried out there is no trouble, and freezing hard is comparatively easy. It is only a question of driving. The sheep are frozen near where they are killed; each is enveloped in a loose linen bag, with the owner's mark on it, and they are stowed in rows and tiers in the holds. No harm can come to them, so long as the temperature is maintained at a certain low figure, and this is easy to accomplish, provided that everything has been properly carried out in the matter of insulation. It is like the case of the ship which has only to drive as hard as its engines and boilers will allow it, without thinking of the cost. If the insulation is good, and even if it is only moderate, low temperatures mean simply more coal and accessories than higher temperatures.

It is when we come to the cases where certain definite temperatures have to be maintained that the difficulties of the problem begin to appear. With "chilled" beef, for instance, which must not be frozen, but is held at about 33 to 35 degrees F., the outer layers will freeze if a much lower temperature is reached, and the condition of the meat on arrival may be seriously deteriorated. On the other hand, if the temperature is allowed to rise to an appreciable extent, the processes of decay, which the low temperature holds in check, may commence, and it is then very difficult to arrest them, particularly as in some cases the processes themselves generate heat. Further, if one quarter of beef commences to decay, the others may take it up. When first received, the meat has to be very gradually and carefully "chilled," or the outer layers may be chilled while the inside is still warm; and the inside meat being protected by the outer layers, the processes of decay may be continued somewhat vigorously. The meat is, therefore, allowed to lose its animal heat, is then very carefully chilled, so that the process goes right in to the bone, and is then maintained at the desired temperature.

For this purpose, in one arrangement the cold chamber is divided into bays, or longitudinal divisions, to each of which is assigned its own brine cooling pipe, or two bays may have a stack of pipes fixed vertically between them, the flow in all the pipes being controlled by valves on the outside of the chamber. Thermometers are fixed in the flow and in the return pipes, so that the attendant can learn what is going on in each bay, and can allow the brine to flow in that set of pipes accordingly. In the case of fruit, it is necessary that there shall be a gentle current of dry air all around each fruit throughout the voyage. Fruit ships are, therefore, fitted something on the lines of frozen mutton carriers, but usually with air cooling only.

(TO BE CONTINUED)

Lloyd's register reports under construction during the quarter ending March 31, 1906, in the United Kingdom, a total of 547 merchant vessels of more than 100 tons each, and aggregating 1,401,882 tons. This makes an average of 2,563 tons. For other countries similar figures are given as follows: Germany, 105 vessels; 284,433 tons; average, 2,709. United States, excluding Great Lakes, 41 vessels; 90,552 tons; average, 2,209. Holland, 35 vessels; 56,992 tons; average, 1,628. Italy, 18 vessels; 54,005 tons; average, 3,000. Japan, 22 vessels; 52,608 tons; average, 2,391. Norway, 29 vessels; 31,126 tons; average, 1,073. France, 15 vessels; 27,888 tons; average, 1,859. Denmark, 9 vessels; 17,355 tons; average, 1,928. Sweden, 12 vessels; 9,650 tons; average, 804. Austria Hungary, 4 vessels; 7,487 tons; average, 1,872. In addition to this a number of vessels were building in other countries and in the British colonies. Of the British total, 511 were steam and 36 sail. None of the sailing vessels exceeded 2,000 tons. Of the steam, three exceeded 20,000 tons; five others were upwards of 10,000 tons; and 52 others, 5,000 tons or above.

The Manufacture of Ships.

When the new steamer *Harvey D. Goulder* was launched at Lorain, O., March 31 by the American Shipbuilding Company. President Wallace took occasion to remark that the process of turning out ships on the Great Lakes had undergone a radical change from that of building them to that of manufacturing them. The point was well taken, and the extreme celerity with which ships are "manufactured" on the Lakes is a good proof of the correctness of the statement. The *Goulder*, which has a length of 545 feet over all, 525 feet on the keel, a beam of 56 feet and a depth of 31 feet, was launched just eight weeks after the keel was laid, and was scheduled to start on her maiden trip with a load of coal three weeks after the launching. This makes the total period of construction only eleven weeks, which is very close to the record. As a matter of fact, however, a number of other recent ships of similar size on the lakes have been put to work in a remarkably short space of time after the laying of the keel, this fact being due to the great amount of standardization in dimensions and details, which has been the result of the last half dozen years' experience in the construction of ships for those great fresh water seas.

A Motor Boat at Full Speed.

As illustrating the difference in wave formation between the disturbance created by a vessel moving at the speed and trim for which she was designed, and at some other speed we present herewith two photographs of the automobile boat *Veritas*, of which the one showing the heavy bow wave, and particularly a great deal of spray, was taken while the boat was running at the rate of 27.27 statute miles per hour, while the other, which shows a much smaller disturbance of the water, was taken at a speed of 29.2 miles per hour.

THE VERITAS AT 27.27 STATUTE MILES PER HOUR.—*Photograph by Robinson, New York.*

The *Veritas*, which was described in some detail in our number for September, 1905, has a length over all of 56 feet 8 inches; a length on the load water line of 54 feet 4 inches; an extreme beam of 7 feet and a draft of 3 feet. She is propelled by an eight-cylinder four-cycle engine of about 200 horsepower, the designed speed being about twenty-nine miles per hour. The designer is Henry J. Gielow of New York.

THE VERITAS AT 29.2 STATUTE MILES PER HOUR.—*Photograph by Levick, New York.*

The photograph at the lower speed shows that the bow has not risen sufficiently to bring the lines into the position aimed at by the designer for full speed conditions, and the resultant difference in the waves formed is very striking. It will be noticed that in both cases the sheet of water thrown up is very thin, because in each case it is possible to see, through it, the contrast between the dark underbody and white upperbody of the boat, the line of division being at the still water load mark. This transparency is particularly noticeable in the case of the boat running at full speed, and it is readily seen that the very thin sheet of water must have been thrown up almost perpendicularly by the bow of the boat going through it, and then the foam further aft on the wave was formed, partly by the toppling over, due to its own weight, of this thin sheet, and partly by contact with the flaring sides of the boat further aft.

Altogether the two views form a striking example of wave making at high speed, and particularly of the different effects experienced under different conditions of speed with regard to the design.

Institute of Marine Engineers.

At the seventeenth annual meeting of the Institute, held May 4, 1906, figures for membership on January 31 were given as 949, as against 928 at the end of the previous year. The finances of the Institute appear to be in good condition, the revenue during the year have amounted to a total of about $4,600, with expenses about $125 less. The balance sheet shows total assets amounting to about $14,300, including the Institute building, which stands on the books at $7,300. The balance on the books to the credit of the Institute appears to be about $11,000.

THE USE OF ALCOHOL AS A FUEL FOR GAS ENGINES.

BY H. DIEDERICHS.

THE FUEL.

Under date of April 17th, 1906, the papers brought the news that the House of Representatives had passed the alcohol bill. By the provisions of this bill domestic alcohol of such degree of proof and such regulations as the commisioner of internal revenue may prescribe may be withdrawn without the payment of an internal revenue tax, for use not only in the arts and industries, but for fuel, light and power. The recent passage of this bill also by the Senate makes a consideration of the properties of alcohol for power purposes of great interest at the present time. Just now alcohol appears to be the only possible competitor of gasoline, kerosene or crude oil for general power work. One may even go a step further than this, and claim that finally alcohol will be *the* fuel for power generation; for while the production of coal and the crude oil products is probably limited in time, alcohol can be grown for all time in the measure that the arts and industries demand it.

The present article will consider the fuel value and the physical properties of alcohol, and the details of the alcohol engine, wherever they may be different from those of a gasoline or crude oil machine. Further, the efficiency and cost question will be briefly discussed.

Ethyl alcohol, whose chemical formula is C_2H_6O, may be made in various ways but the commercial alcohol of to-day is the result of fermentation, generally of grape sugar, in the final stage. The raw materials are various. Thus, according to Sand* they may be divided into three classes:

1. Those containing starch,—potatoes, with 15 to 24 percent starch,
   rye, with 50 to 56 percent starch,
   corn, with 60 percent starch.
2. Those containing sugar,—sugar beet, with 8 to 18 percent sugar,
   sugar cane, with 12 to 16 percent sugar.
3. Those containing alcohol,—wine with 9 to 16 percent alcohol.

The method of manufacture, of course, varies with the raw material, but need not be described in detail here. Theoretically, 100 pounds of grape sugar should yield 51 pounds of pure alcohol; in reality the yield is from ⅛ to ⅓ less than this amount.

A second method of producing alcohol, notably mentioned by Witz in his "Moteurs à Gaz et à Pétrole," is to start with calcium carbide as a raw material. This, by a somewhat complicated process, can be changed from CaC_2 through the stages of C_2H_2 and C_2H_4 to alcohol, C_2H_6O. Barium carbide or strontium carbide can be used in the same way. Witz states that from 1 kilogram (2.2 pounds) of calcium carbide 0.8 liter (1.69 pints) of alcohol can be obtained; this is equivalent to 0.096 United States gallons of alcohol from 1 pound of carbide. Estimating the price of carbide at 3 cents per pound, which is even now somewhat below the market price, 1 gallon of alcohol would therefore cost, in raw material alone, 31.2 cents, to say nothing of the cost of the chemical operations. The by-products in the case of the calcium carbide do not amount to much. There is consequently little likelihood that the so-called synthetic or mineral alcohol will ever seriously compete with gasoline or kerosene for power, as will be shown later.

The heating value of alcohol can not be accurately computed from its chemical composition, because nothing definite is known of the arrangement of the atoms entering the composition. We therefore have to depend upon the calorimeter. The figures determined for absolute alcohol by various experimenters are as follows:

	Higher heating value per pound	Lower heating value per pound
Thompson,	13,310 B. T. U.	12036 B. T. U.
Favre & Silberman,	12913 "	11664 "

The value 11664 B. T. U. is the one most generally used. Absolute alcohol has a specific gravity of 0.7946 at 15° C (59° F), so that one gallon of pure alcohol weighs 6.625 pounds, and has a lower heating value of 77,274 B. T. U.

One pound of C_2H_6O contains 0.522 pound carbon, 0.130 pound hydrogen, and 0.348 pound oxygen.

According to this there will be required for the combustion of one pound of absolute or 100-percent alcohol

$$\frac{(0.522 \times 2.66) + (0.130 \times 8) - 0.348}{0.23} = 9 \text{ pounds of air.}$$

This is the equivalent of 111.5 cubic feet of air at 62° F. per pound of C_2H_6O. Commercial alcohol, however, is never pure, but nearly always contains a certain quantity of water, the admixture being measured according to volume percent. Thus, 90-percent alcohol means that the mixture carries 10 percent by volume of water. The heating value of such alcohol is of course correspondingly reduced from that of 100-percent alcohol according to the following table, due to Schöttler:

Absolute alcohol volume—percent	Specific gravity	Absolute Alcohol weight—percent	Lower heating value per pound B. T. U.
95	0.805	93.8	10880
90	0.815	87.7	10080
85	0.826	81.8	9360
80	0.836	76.1	8630
75	0.846	70.5	7920
70	0.856	65.0	7200

It is required by law, in countries where alcohol is now used in the industries, to so fix the fuel that it is rendered undrinkable. This process is called "denaturizing" the alcohol. The bill at present before Congress provides for the same thing. The materials used for this purpose differ in the various European countries. Some of them try to keep the process a secret, hence some of the information given in the following table* is based upon analyses.

MATERIALS USED TO DENATURIZE ETHYL ALCOHOL.

Country	Sp.Gr. of Denaturized Alcohol at 15° C	Methylene (wood alcohol (and its impurities percent	Pyridine or Pyridine Bases percent	Acetone percent	Benzol percent	Benzine percent
France	0.832	7.5	—	2.5	—	0.5
Germany.						
Denat. Alcohol	0.810	1.5	0.5	0.5	—	—
Motor Alcohol	0.825	0.75	0.25	0.25	2.0	—
Austria						
Denat. Alcohol	0.835	3.75	0.5	1.25	—	—
Motor Alcohol	0.826	0.5	trace	trace	2.5	—
Russia	0.836	10.0	0.5	5.0	—	—
Italy						
Motor Alcohol	0.835	6.5	0.65	2.0	1.9	—
Switzerland	0.837	5.0	0.32	2.2	—	—

It will be noted from the table that the material most used for denaturizing ethyl alcohol is wood alcohol. The heating value of the fuel is by the addition of the denaturizing liquid changed but little in most cases.

Benzol, C_6H_6, besides being used for denaturizing, is sometimes used in larger quantities than indicated in the above table for the purpose of increasing the heating value of the fuel mixture per pound. Benzol has a specific gravity of 0.866 and a heating value of 17100 B. T. U. per pound. A mixture of *x*

*Sand, *Zeitschrift des Vereines deutscher Ingenieure*, 1904, page 933.

Zeitschrift des Vereines deutscher Ingenieure, June, 1905.

percent by weight of absolute alcohol with y percent of benzol will therefore have a heating value of

$$[11664\ x + 17190\ y]\ \text{B. T. U. per lb}$$

If the alcohol is not absolute, its proper heating value should

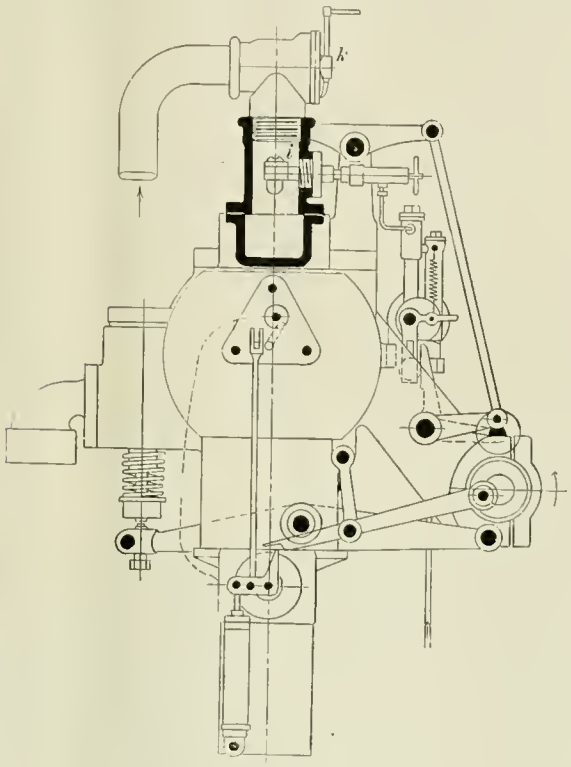


FIG. 1.

be substituted from the table above given. In this way from 10 to 40 percent of benzol is sometimes employed, thus raising the heating value of the fuel, and at the same time decreasing the specific heat cost, i. e., the cost per heat unit.

There is a second reason why benzol is employed. Under certain circumstances there will be formed acetic acid in the products of combustion of alcohol. This causes rusting of the engine parts. On examination it will be found that this is due to a combustion with insufficient air supply, and the surest way to prevent rusting therefore is to use a good excess of air, and to have a perfect mixture. Under such conditions there will be no danger of corrosion. It is also found that a good addition of benzol acts as an additional safe-guard. It should not be forgotten in this connection, however, that the great advantage possessed by alcohol in its odorless exhaust is sacrificed to some extent by the use of benzol.

THE ENGINE.

Taking up next the mechanical details of the alcohol engine, we find that they do not differ materially from those of the ordinary gasoline engine. As a matter of fact, any gas or gasoline engine can be run on alcohol, if only a means be provided to form the fuel mixture. The first trials with alcohol were made on liquid fuel engines so provided. It was soon discovered, however, that the efficiency of operation of alcohol engines could be materially increased, if the compression were increased above that possible for gasoline. Hence this is the main point of difference between gasoline and alcohol engines. The other point is the one above mentioned, i. e., that a different vaporizer or carburetor is required.

There has naturally been very little work done on alcohol engines on this side of the water. In Europe, however, especially in Germany and France, there are to-day many alcohol engines in operation, used mostly in agricultural industries. For this purpose the other advantages possessed by alcohol overbalance the somewhat greater operating costs. One such advantage is the greater safety of alcohol as compared with gasoline, which makes the packing and shipping so much easier, and the conditions imposed by insurance companies much less strict and hence less irksome, to say nothing of the lower cost of insurance. Again, the production of alcohol is not confined to certain localities, as is that of a product like crude oil, gasoline or kerosene. It may be grown and made almost anywhere, and hence the freight charges to the consumer will in most cases be comparatively smaller than for the crude oil products.

It is therefore to Germany that we have to look for information regarding alcohol engines. The following material is taken mainly from the work of E. Meyer* and of R. Schöttler**, and from the discussions of Güldner†, Diesel†† and others, published in the *Zeitschrift des Vereines deutscher Ingenieure*. To all these the writer desires to render his acknowledgment.

Regarding the formation of the fuel mixture with alcohol, it is found that it is less volatile than gasoline, but easier to handle than kerosene. In nearly all of the vaporizing devices for alcohol now on the market, the agency of heat, usually the exhaust heat of the waste gases, is used to aid in the formation of the mixture. This scheme has the drawback that no heat is

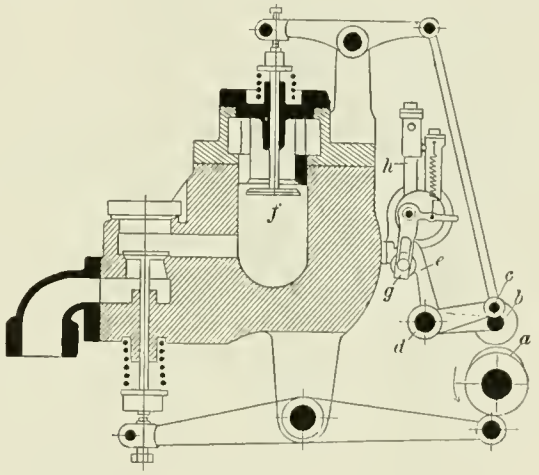


FIG. 2.

available at the start when the engine is cold, and it is next to impossible to start a cold engine on alcohol. To avoid an open flame for the purpose of heating the vaporizer at the start, which is both dangerous and cumbersome, the engines in most cases are started with gasoline, and when, after a few strokes, enough heat is available, the change is usually made by throwing over a single lever. In tests of ten different engines made by Meyer, it was shown that this change to alcohol could be made in the slowest case in 6 minutes and 40 seconds, the time of the fastest being 55 seconds.

Based on the manner of heating the vaporizer, we can distinguish the following classes:

1. Those in which no heat is employed.
2. Those in which the air is preheated.
3. Those in which the mixture is heated and superheated.

Of the first type is the Deutz, Figs. 1 and 2. When the engine is regulated by the throttling method, and not by the hit and miss system, it has been found that no preheating of air or fuel mixture is required. The reason for this is undoubtedly that in a hit and miss engine, under less than normal load, a succession of misses cools the cylinder down so far as to throw

*E. Meyer. *Zeitschrift d. V. d. I.*, 1903, pages 513, 600, 632, 669.
**R. Schottler, " " " " " 1902, pages 1157, 1223.
†H. Guldner, " " " " " 1902, page 623.
††R. Diesel, " " " " " 1903, page 1366.

down some of the alcohol vapor on the next explosion, unless it is superheated. The Deutz engine is governed by throttling. The inlet valve, *f*, is actuated through the levers shown, by the cam, *a*, which is of taper form and under the control of the governor. Upon the position of *a* depends the length of time the valve, *f*, is open. Through the bell crank, *c d e*, the cam also acts upon the plunger of the fuel pump, *h*, operating in such a way as to cause suction during the first part of the cam movement, and pumping of the liquid during the second. Thus the fuel is injected during the second half of the suction stroke only, insuring a rich mixture around the igniter. The alcohol is forced through the sprayer or atomizer, *i*, Fig. 1, into the current of air which enters through the valve, *k*. Thus no preheating whatever is done, but the atomizing is thorough; and the ports into the cylinder are as direct and short as possible, hence no vapor is thrown down.

The Altman vaporizer, Fig. 3, is of the second class. The air pipe *a—b* is surrounded at its lower end by the exhaust pipe; the air is thus preheated by the exhaust gases. A regulating valve for the air is placed at *c*. This, when drawn upward, decreases the amount of air passing, but always makes the air

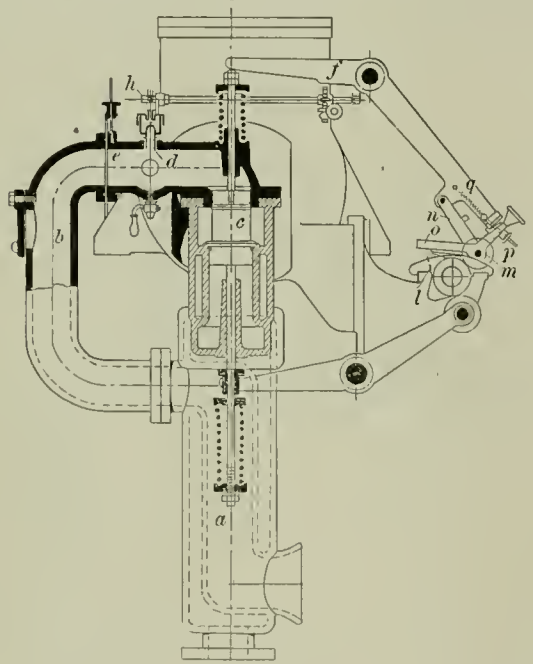


FIG. 3.

current strike through the upper part of the pipe, in this manner directing it always against the fuel nozzle, *d*. The inlet valve, *c*, is operated by the lever, *f*, actuated by the cam, *l*, through the pendulum hit and miss governor *o m p*. This valve lever, *f*, at the same time opens the fuel valve, *d*, through the reach rod shown and the finger, *h i*, Fig. 5. How this is done is shown in Fig. 4. The lever, *f*, on being depressed, forces down the point of the screw, *k*, thereby turning the reach rod about its axis, which depresses the point, *i*, Fig. 5, opening the valve *d*. The amount of opening depends upon the position of the screw, *k*, and this can be very finely adjusted by the worm and wheel arrangement shown. In this vaporizer the fuel supply is atomized partly by the current of air, and is afterwards vaporized by the heat of the preheated air.

The following three vaporizers are of the third class. Fig. 6 shows the Swiderski-Longuemarre. Here also the exhaust gases are used for heating. They pass through the annular chamber, *a*, and their action is aided by the radiating webs *b—b*. The float, *d*, maintains a constant level in the supply chamber. From this chamber the flow of alcohol is regulated by the needle valve, *f*. The liquid flows into the space *g*, and overflows through a number of small openings, *h-h*. Air entering through *i* is made to pass partly outside, partly inside the concentric spaces created by the sleeve, *k*. The amount of air passing outside is regulated by the openings, *n—n*, which are controlled by the lever, *l*. The air currents passing upward carry along with them some of the liquid, the mixture being heated by the exhaust gases in *a*. The perforated plate, *o*, tends to aid in forming a uniform mixture.

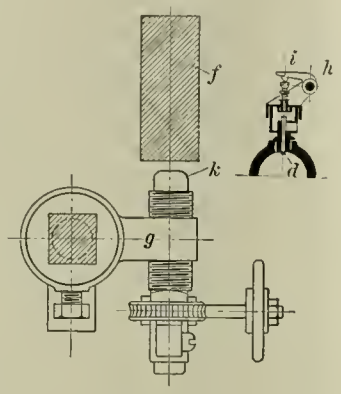


FIG. 4. FIG. 5.

The vaporizer of the Dresdener Gasmotorenfabrik is shown in Figs. 7 and 8. In this case the warm cooling water of the engine is used for heating. It enters the water space at *x*. On very cold days the vaporization may be assisted at the start by pouring some hot water into the funnel, *a*. Air enters at *y*. The inlet valve, *b*, is automatic. It may be pushed down at will at the start by pressing down on the projecting stem, *c*. The downward movement of the inlet valve opens the fuel valve, *d*, to which alcohol is furnished through the needle valve,

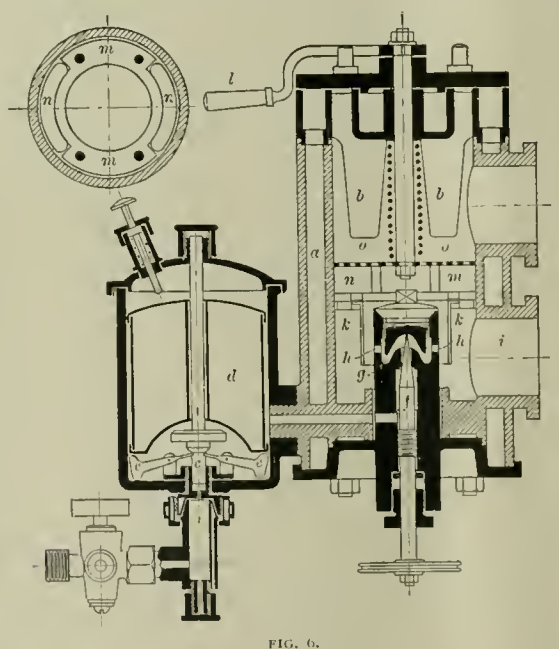


FIG. 6.

c, Fig. 8. Through a number of fine openings the fuel flows into the current of air and is carried along with it, the thorough mixing being assisted by the current striking the cone, *g*. As will be seen from the drawing, the heating of the charge can not be very high. In the first place only the comparatively cool jacket water of the engine is used, and secondly the mixture itself is not in the heated chamber for any length of time.

In contradistinction to the Dresden vaporizer, the Dürr, Fig. 9, produces a highly heated mixture. Air enters at *x* and its amount is regulated by the throttle valve, *a*. The inlet valve, *b*,

is automatic. Alcohol is supplied through the needle valve, *c*, as shown, so that when *b* is closed no flow of alcohol takes place. The current of air charged with alcohol particles passes down through *d*, up the annular space, *e*, and out at *y* to the cylinder. The exhaust gases enter at *z*, and by means of baffle plates are made to take the course shown by the arrows, through the space *f*. Further, the space *e* is filled with a large number of metal spirals, which connect the outside wall of *e* with its inside wall, thus furnishing a large heated surface to the passage of the charge, and facilitating the transfer of heat from the space *f* to the space *d*. Every possible way is therefore made use of to apply the heat of the exhaust gases, and this vaporizer therefore furnishes a mixture more highly superheated than that of the others.

Finally, Fig. 10 shows what may be called a double float carburetor, which is the form that alcohol vaporizers are likely to take. This is used on the Marienfelde machines. Assume that the chamber *a* is used for gasoline, *b* for alcohol. The needle supply valves can be held closed by the springs *c* and *d*, as shown.

On starting with gasoline, the chamber *a* is used. Spring *c* is pushed aside so that fuel can enter, being kept at constant level by the float. The valve, *g*, is so set that the path is open

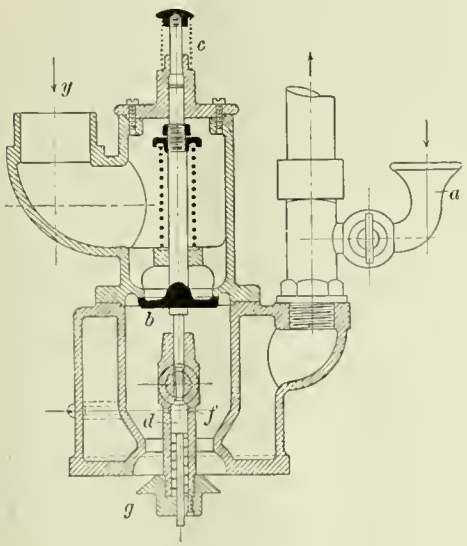


FIG. 7.

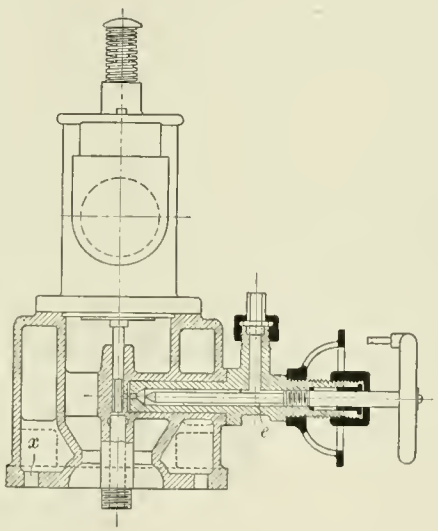


FIG. 8.

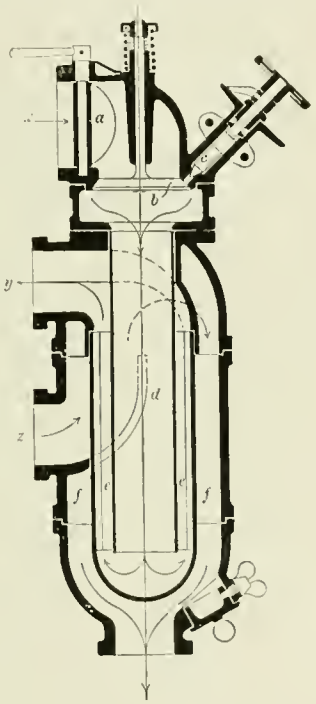


FIG. 9.

for the air from *h* past the gasoline nozzle, *c*, through *g* into the cylinder. At every suction stroke the inrushing air is then charged with gasoline issuing in a small jet from *c*. If it is desired to change to alcohol, spring *c* is pushed into place, spring *d* is pushed aside, and valve *g* is thrown over into the position shown in Fig. 10, all the work of a moment. The air supply to this vaporizer is preheated.

It is quite evident from an examination of the vaporizer above described that the final temperature of the mixture is different in the different devices. Upon this temperature, however, depends in a great measure the only other point of difference between gasoline and alcohol engines, i. e., the amount of compression. All other things being the same, that fuel mixture entering the cylinder at the highest temperature will soonest give rise to preignition, or at least to pounding, under an increase in compression. High temperature of charge also affects engine capacity unfavorably. It therefore becomes important to determine approximately the *lowest* practical temperature of vaporization, and the heat necessary.

Of course the amount of heat required depends upon the amount of alcohol (and its purity) per pound or cubic foot of air. Assuming that 90-volume-percent alcohol is used, the theoretical amount of air required for perfect combustion is 7.8 pounds. Assuming that an excess of 50 percent of air is used, which is a desirable allowance, 1 pound of 90-percent alcohol would require in round numbers 11.7 pounds of air. With the air temperature at 60° F,. and the atmospheric pressure 14.7 pounds per square inch, this amounts to 0.0065 pound of 90-percent alcohol per cubic foot of dry air.

90-percent (volume) alcohol is equivalent to 87.7 (weight)-percent, so that 1 pound of air will carry, according to the above assumed ratio of mixture,

$$0.877 \times \frac{1}{11.7} = 0.075 \text{ pound of absolute alcohol,}$$

and $$0.123 \times \frac{1}{11.7} = 0.010 \text{ pound of water.}$$

To compute the air temperature required so that it may take up the above quantities of alcohol and water vapor, we must know the relation between the temperature and the degree of saturation. Meyer in his computations used the data contained in the Physikalisch-Chemische Tabellen of Landoldt & Börnstein. For our purpose the figures of the table have been transposed into English units.

Temperature Degs F.	Vapor Tension Inches Mercury		1 pound of air contains in saturated condition, i pounds			
			At 28.95 inches Hg. Press.		At 26.95 inches Hg. Press.	
	Alcohol Vapor	Water Vapor	Alcohol Vapor	Water Vapor	Alcohol Vapor	Water Vapor
50	0.950	0.359	0.055	0.008	0.061	0.009
59	1.283	0.500	0.075	0.011	0.084	0.013
68	1.733	0.687	0.104	0.016	0.117	0.018
77	2.325	0.925	0.144	0.022	0.162	0.025
86	3.090	1.240	0.200	0.031	0.227	0.036
104	5.270	2.162	0.390	0.063	0.450	0.072
122	8.060	3.620	0.827	0.135	1.002	0.164

In the ordinary case the air drawn into the vaporizer is not dry, but contains a certain quantity of water. Assume that the air is at a temperature of 59° and just saturated. At a pressure of 26.05 inches of mercury this would correspond to 0.013 pound of water per pound of air in its initial condition. Now in the

case of the average mixture above computed, the temperature of vaporization must be high enough to vaporize an additional 0.010 pound of water, making the total 0.023 pound that the air must contain per pound. It is seen from the table that a temperature of 77° is quite sufficient to do this. It is also seen that at this temperature the air may take up 0.162 pound of absolute alcohol, while the quantity in the above mixture is only 0.075 pound per pound of mixture. At a temperature of 77° the mixture ready for the cylinder may therefore contain the alcohol vapor in a state of some superheat. If therefore the temperature of the walls with which the mixture comes in contact is not less than 77°, no fear of condensation of alcohol vapor need be entertained. In this connection a statement in the *Engineering Record* is of interest. It is there claimed that the

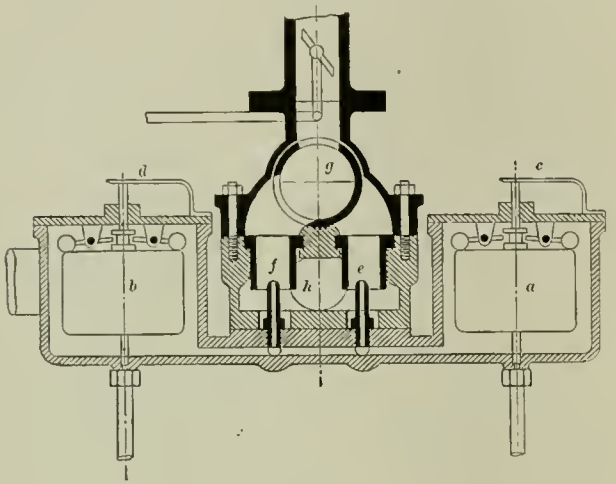


FIG. 10.

consumption of alcohol with the jacket water leaving at 60° F is 100 percent higher than with jacket water leaving near 212°; i. e., with cooling by vaporization. In the light of the above facts, some such increase in the consumption is quite possible.

In order to convert the liquid alcohol into vapor, a certain quantity of heat is required. According to Regnault, this amount is, for the various temperatures given, and computed above 32° F, as follows:

At 32° F	425.7	B. T. U. per pound
68° F	453.6	" " "
122° F	475.2	" " "
212° F	481.1	" " "

The specific heat of liquid alcohol is close to 0.6, so that in order to convert the quantity of 90 volume-percent alcohol contained in the assumed mixture, to alcohol vapor at 77° F, would require approximately, assuming the liquid alcohol at 60° F.

$$0.075 \times [458 - (28 \times 0.6)] + [0.010 \times 1100] = 44.1 \text{ B. T. U.}$$

where 1100 B. T. U. is assumed as the heat of vaporization of water under the existing conditions

Now the heating value of 90 volume-percent alcohol has been shown to be 10080 B. T. U. per pound, so that the heating value on one pound of our assumed mixture will be $0.075 \times 10080 = 756$ B. T. U. The heat of vaporization required is therefore $\frac{44.1}{756} = 5.8$ percent of the heating value of the fuel. It can be shown that the amount of heat is easily obtainable from the exhaust gases. It can also be shown that the problem may be solved by preheating the air only, for, assuming that the specific heat of air at constant pressure is 0.238, we would have to preheat the air for the assumed mixture to $\frac{44.1}{.238} + 77 = 262°$ F, which is easily possible.

If, on the other hand, not the air but the mixture is heated, then the walls need to have a temperature only sufficiently higher than 77° to transfer the required amount of heat for vaporization to the mixture in the time available. To furnish more heat than this is harmful, if anything, for it affects unfavorably both the possible degree of compression and the capacity of the machine. The cooler the mixture after formation and vaporization, the better.

This point was strikingly brought out in the tests made by E. Meyer in 1902. As above explained, the Deutz vaporizer uses no heat either for the air or the mixture. The walls of the chamber near the atomizer felt cold to the touch, and during the tests were covered with water vapor. This shows conclusively that the alcohol in the mixture could not have been completely vaporized. The ports from the atomizer to the cylinder are in the case of the Deutz engine very direct and short, so that probably no serious separation of liquid occurs. Once in the cylinder the vaporization is quickly effected, for the cylinder walls are hot, the method of cooling used being that by vaporization. In any case, however, the final mixture is comparatively cool, and the degree of possible compression correspondingly high, the ratio of compression during the tests being 8.9.

The Dürr vaporizer, on the other hand, gives the most highly diffused and highly heated mixture. A highly diffused, i. e., a perfect mixture, of course affects the alcohol consumption favorably, and for that reason the consumption of the Dürr engine per horsepower-hour was not much greater than that of the Deutz. But the high temperature of the mixture compelled the use of a lower degree of compression, the ratio used being 6.68, and even at this point the explosions in the Dürr engines were sharper than those in the Deutz. If the Dürr machine had been able to use the same degree of compression as the Deutz, Meyer figures that its fuel consumption would have been lower than that of the latter.

It may be asked why a higher compression should show a better fuel consumption per horsepower-hour, i. e., a better thermal efficiency. It can be shown on theoretical grounds that the thermal efficiency of an Otto cycle can be expressed by

$$E_t = 1 - \frac{1}{r^{n-1}}$$

where r = ratio of compression = ratio of $\frac{\text{total cylinder volume}}{\text{clearance volume}}$

$$n = \frac{C_p}{C_v} = \text{ratio } \frac{\text{specific heat of charge at constant pressure}}{\text{specific heat of charge at constant volume}}$$

Evidently E_t is the greater, the greater the value of r, i. e., the smaller the clearance volume, and hence the higher the compression. And it is found that this theoretical formula is borne out in practice.

The best results so far attained in practice have been with a compression pressure of about 200 pounds. The average compression pressure for good results may be taken at 180 pounds. The corresponding maximum explosion pressure is about 450 pounds.

With the exception of the carburetor and the compression, the design of the alcohol motor does not differ from that of a gasoline machine, as is shown by Fig. 11, which represents a two cylinder launch engine built by Marienfelde. Alcohol is contained in the vessel, *a*, which is filled through the strainer, *b*. The tank, *a*, is kept under a certain definite pressure by means of the exhaust gases, which forces the alcohol into the left hand float chamber of the vaporizer, *c*. Part of the exhaust gases pass through the strainer, *f*, the check valve, *h*, and the pipe, *e*, to the fuel tank. *g* is a safety valve, so that by means of this and the check valve, *h*, a constant pressure is maintained on the liquid in the tank. The inlet valve, *i*, is automatic, while exhaust valve, *k*, is mechanically operated. The fresh air passes through a heater surrounding the exhaust pipe and is thus preheated on its way to the vaporizer. The volume of these preheaters is made from 0.12 to 0.15 of the stroke volume. Ignition is produced by means of the electro-magnetic apparatus *l, m* being the make and break gear. Regulation is effected by the hit and miss system. *n* is a small rotary pump, driven as shown.

to furnish circulating water for the jacket. The supply of gasoline required to start the machine is kept in a tank *d*, at higher level, so that the fuel is supplied to the right hand float chamber by gravity. The operation of the vaporizer was explained under Fig. 10.

The following table of dimensions of Marienfelde engines gives some idea of the size of the machines:

Maximum Brake Horsepower	R. P. M.	Cylinder Diameter Inches	Stroke Inches
8.0	220	6.70	11.80
13.2	220	7.90	14.20
21.0	202	9.85	15.75
24.5	200	11.00	15.75
30.0	200	13.80	15.75

EFFICIENCY.

There remains to be considered the efficiency of the alcohol engine and the cost of operation.

Again, next to nothing has been published in this country regarding these points, and we are compelled to turn to other sources. The most extensive testing work has been done by E. Meyer in 1902, for the German Agricultural Society. While the results there obtained were uniformly good, they have been bettered since then, mainly through a further increase in compression. The cost of operation is of course intimately related to the efficiency, and the two will therefore be considered together.

Regarding the specific heat costs of gasoline, kerosene and alcohol, the price of gasoline may be assumed at an average of 15 cents per gallon, that of kerosene at 13 cents. The price of denaturized alcohol is of course still undetermined as far as this country is concerned. In Germany 90 volume-percent alcohol was sold at 15 pfennige per kilogram in 1902. This is equivalent to about 11.5 cents per gallon. In 1905, however, the price of alcohol was raised to 25 marks per 100 kilograms, i, e., to 19 cents per gallon, by the alcohol trust. Regarding the United States, the only reference the writer has been able to find is contained in the *Iron Age*, March 15, 1905. At a hearing of the Ways and Means Committee, Mr. Kline, representing the Philadelphia Trades League, brought out the following facts, referring to a distillery located in Illinois:

"The cost of production has fallen as low as 5.2 cents per proof gallon, equal to 9.77 cents per wine gallon testing 94 percent, or 9.36 cents per wine gallon testing 90 percent.

"The average cost per proof gallon during the entire period of 10 years was 10.78 cents, equal to 20.26 cents per wine gallon, 94 percent, or 19.4 cents per wine gallon, testing 90 percent.

"The average cost of corn during the entire period of ten years covered by these records was 42.36 cents per bushel, and the average yield from each bushel was 4.76 proof gallons."

It was further mentioned that alcohol, to be used for beverage purposes, or for use in manufacturing perfumery, flavoring extracts, etc., can be made from merchantable grain only. For the production of denaturized alcohol, however, inferior materials could be employed, thus cheapening production.

In view of the above facts it seems improbable that alcohol testing 90 percent, from merchantable raw material, will ever be sold for much less than 20 cents a gallon. But assuming that the use of inferior raw materials may eventually bring its cost down to 15 cents per gallon, the specific heat costs of the liquid fuels mentioned would be as per table:

Fuel	Heating Value per Pound B. T. U.	Cost per Gallon Cents	Cost per Pound Cents	Specific Gravity	Cost of 10000 B. T. U. Cents
Gasoline	19000	15.0	2.57	0.710	1.35
Kerosene	18500	13.0	1.88	0.800	1.02
Alcohol, 90 percent	10080	15.0	2.21	0.815	2.19

It is seen at once that alcohol is saddled at the outset with a very serious handicap in the way of greater specific heat cost, as compared with either gasoline or kerosene. To be on a par, therefore, regarding cost of operation, the thermal efficiency of the alcohol engine would have to be $\frac{2.19}{1.35} = 1.62$ times greater than that of gasoline, and $\frac{2.19}{1.02} = 2.15$ times greater than that of kerosene, everything else in the way of engine losses being the same. It remains to be seen how far this has been realized in practice.

In 1903 Diesel found the best figures for the thermal brake efficiencies of gasoline and kerosene engines so far attained to be 20.5 percent for gasoline and 17.6 percent for kerosene. This corresponds to a consumption of 0.654 pound of gasoline and

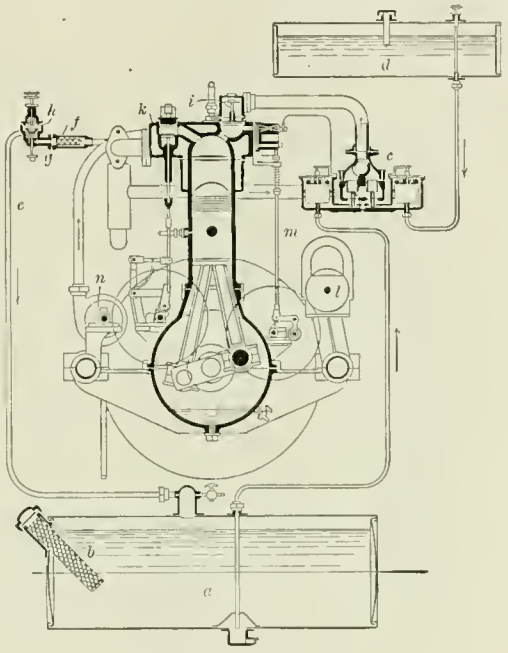


FIG. 11.

0.727 pound of kerosene per brake horsepower-hour. Banki, with his water injection principle, had reached as high as 27.5 percent thermal brake efficiency, equivalent to 0.487 pound of gasoline per brake horsepower-hour, but this is a special case. Allowing for some further improvement in gasoline and kerosene engines since 1903, we will assume the best thermal brake efficiency for gasoline 23 percent, and for kerosene 18 percent.

The best figure obtained by Meyer in the competitive tests of 10 alcohol engines in 1902 was 395 grams of 90 percent alcohol per brake horsepower-hour for the Deutz engine. This corresponds to 0.803 pound of alcohol per brake horsepower-hour and a thermal efficiency of 31.7 percent. The end compression in this case was about 190 pounds, the explosion pressures exceeded 450 pounds per square inch. It is possible to increase this high efficiency by the use of still higher degrees of compression, but it is questionable whether the use of such high compressions is advisable in average practice. The maintenance and care of the machine become more and more difficult, and it becomes very sensitive to improper setting of the fuel supply valve, pounding and knocking and otherwise unsteady running occurring very easily.

The use of benzol-alcohol mixtures has already been mentioned. The cost of benzol will probably not be very far different from that of denaturized alcohol, but on account of its

greater heating value, its specific heat cost is less. The use of a 15-percent benzol-85-percent alcohol mixture has shown in Meyer's tests about the same thermal efficiency as that of alcohol alone. Hence the cost of operation with these benzol mixtures may be slightly less than that for alcohol. In spite of this fact, the use of much benzol is not advisable, because it fouls the engine after a while, making cleaning necessary from time to time.

The above economy and cost figures are collaborated in the following table:

Fuel	Cost for 10000 B. T. U. Cents	Best Consumption of Fuel per B. H. P. hr. Pound	Best Thermal Brake Efficiency Percent	B. T. U. per B. H. P. hr.	Fuel Cost Per B. H. P. hour Cents
Gasoline	1.35	0.580	23.0	11000	1.485
Kerosene	1.02	0.725	18.0	14140	1.442
Alcohol, 90 percent	2.19	0.803	31.7	8030	1.758

It appears therefore that at the present time, with 90-percent alcohol at 15 cents per gallon, the operation with alcohol would cost about 19 percent more than with gasoline, and about 22 percent more than with kerosene, the prices for the latter being as assumed above. It is to be hoped that this margin can be overcome, either by perfecting the machine, or by decreasing the cost of the fuel. On the basis of the above computations, 50-percent alcohol, for instance, would have to cost 12 cents a gallon, to be on a par with gasoline. The advantage of gasoline with regard to fuel cost, however, is even now not so great but that it is largely overbalanced by the already mentioned advantages of the alcohol machine, and that is the real reason why the latter has found such extended application in some European countries, in spite of its slightly greater operating cost.

Progress of Naval Vessels.

The Bureau of Construction and Repair, Navy Department, reports under date of May 10, 1906, the following percentage of completion of vessels building for the United States Navy:

			Apr. 1	May 1
BATTLESHIPS.				
Nebraska	19 knots.	Moran Brothers Co.	92.	92.65
Georgia	19 "	Bath Iron Works	95.75	95.58
New Jersey	19 "	Fore River Shipbuilding Co.	98 5	99 5
Connecticut	18 "	Navy Yard, New York, N. Y.	97.11	97.41
Louisiana	18 "	Newport News Co.	97 92	98.08
Vermont	18 "	Fore River Shipbuilding Co.	79 3	83.8
Kansas	18 "	New York Shipbuilding Co.	75.7	78.5
Minnesota	18 "	Newport News Co.	85.27	88.28
Mississippi	17 "	Wm. Cramp & Sons	52.84	54 88
Idaho	17 "	Wm. Cramp & Sons	51.44	53 52
New Hampshire	18 "	New York Shipbuilding Co.	40.4	42.5
ARMORED CRUISERS.				
California	22 knots.	Union Iron Works	01.9	92.8
South Dakota	22 "	Union Iron Works	89.8	90.4
Tennessee	22 "	Wm. Cramp & Sons	96.37	97.51
Washington	22 "	New York Shipbuilding Co.	96.	97.3
North Carolina	22 "	Newport News Co.	39.97	42 73
Montana	22 "	Newport News Co.	35.4	38.24
SEMI-ARMORED CRUISERS.				
St. Louis	22 knots.	Neafie & Levy Co.	93.37	95.66
Milwaukee	22 "	Union Iron Works	92.5	94.3
SCOUT CRUISERS.				
Chester	24 knots.	Bath Iron Works	26.15	29.44
Birmingham	24 "	Fore River Shipbuilding Co.	28.6	31.3
Salem	24 "	Fore River Shipbuilding Co.	28 9	32.2
SUBMARINE TORPEDO BOATS.				
Submarine No. 9		Fore River Shipbuilding Co.	63.9	68.2
" " 10		Fore River Shipbuilding Co.	52 5	53.5
" " 11		Fore River Shipbuilding Co.	58.2	60.5
" " 12		Fore River Shipbuilding Co.	51.4	53.8

A LARGE SHIPBUILDING CRANE.

Some months ago the Brown Hoisting Machinery Company of Cleveland, O., erected in the plant of the Harland & Wolff Shipbuilding Company of Belfast, Ireland, a noteworthy crane, between two building slips, and so adjusted as to serve these slips splendidly in the way of delivery of material, etc. Our photograph shows that this crane consists in the main of three parts,—one being the immense steel trestle upon which the moving members are mounted, the second being a traveling crane on top of the trestle and with arms extending out on either side, and the third being two cantilever cranes, one on each side of the vessel, and independently operated.

The trestle is made partly of iron and partly of steel, and has a length over all of 674 feet, the width between centers of posts being 18 feet. At the front or water end the height of the trestle above foundation is 123 feet 5 inches, while at the rear end this height is 119 feet 5 inches, the difference being due to the slope of the ground, as of course the rails on top are perfectly level. The posts or bents of the trestle are of built-up sections, made in such shape as to require no intermediate bracing in the direction of the length of the trestle, as the columns are of sufficient width to give the necessary moment of inertia for stiffness. They are pinned at the top to the bottom cords of the bridge trusses, and at the bottom to the regular foundation plates. Longitudinal stiffness of the entire trestle is assured by an A-frame strut at the center, and fitted with pin connections at top and bottom. This makes a fixed point from which the bridge trusses are free to expand each way through the medium of the pin connections with the vertical posts. The whole arrangement covering longitudinal strength and stiffness is such as to leave a free and clear space between posts and under the trestle, for the stowage and handling of material. The posts are spaced about 65 feet apart in the longitudinal direction.

The bridge truss on top, as will be noted from the photograph, is of the familiar diagonal braced type, with a height of about 18 feet. The continuous plate girders, forming the supports for the cantilever cranes and the top and bottom cords, and the vertical trusses constitute together a rigid system of lateral bracing. Both the bridge truss and the supporting posts are braced in the other direction by means of diagonal tie rods. Horizontal struts are fitted between the two columns in each pair of posts at such vertical distances apart as to give the diagonal tie rods an angle of about 50 degrees with the horizontal.

The tracks for the upper crane have a gauge center to center of 18 feet, and are fitted at each end with special safety stops. The tracks for the special cantilever cranes also extend the entire length of the trestle, and are specially designed for taking the loads necessary in operation.

The overhead crane is of the standard type, with a total trolley travel of 216 feet 4 inches, and consists of a double balanced cantilever, the lower member of which is 32 feet in the clear above the tracks on which the crane travels. The maximum load which this crane is fitted to handle is 5 tons. The crane is so designed that as the trolley travels along its runway in either direction on the cantilever a suitable counterweight above the trolley moves in the opposite direction, and assists in counterbalancing the load.

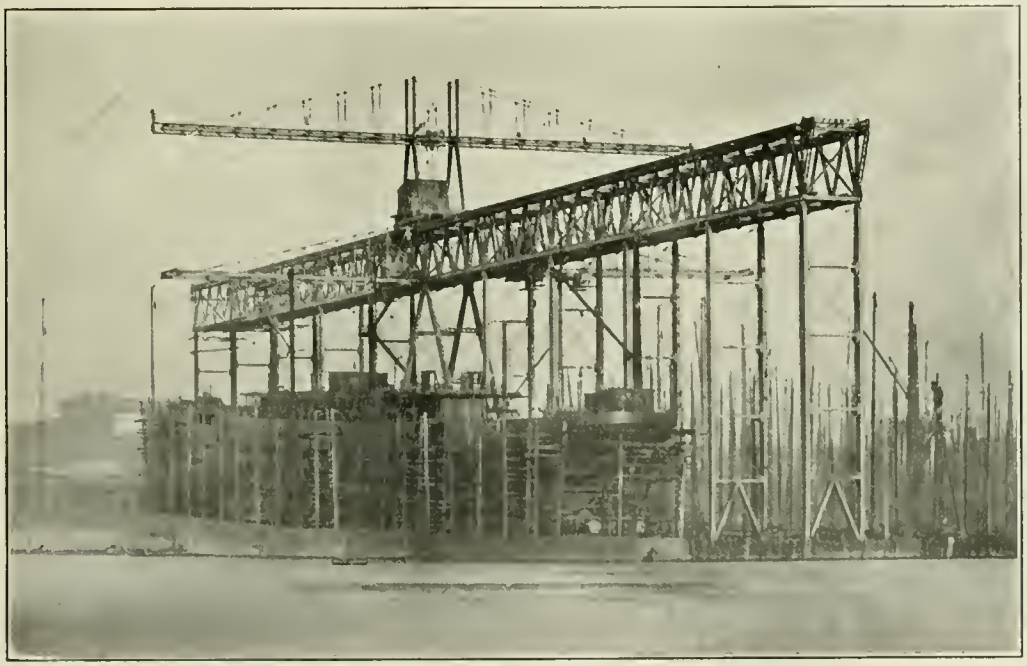
The side cantilever cranes travel on special tracks so constructed that the pull due to the weight of the cantilever arm and its load is taken up at the top by equalizing trucks. At the same time the corresponding compression at the bottom is taken care of in a similar manner. A vertical load is taken by equalizers carrying wheels which run upon the top of the bottom truss of the trestle, these wheels being the ones which operate the longitudinal travel of the crane. Each of these cantilever cranes is equipped with two electric traveling cranes having each a maximum working capacity at the center of the span of 10 tons. The side cantilever is so designed that when

one of these traveling cranes is at the maximum distance (102 feet 4 inches) from the center line of the trestle, the other must be distant from that center line not more than 35 feet, with similar proportions at intermediate points. In other words, the sum of the distances of the two cranes from the center of the trestle must not exceed 137 feet. This limitation applies only to the full load. With a load of 8 tons, however, or less, the two cranes may be operated at the extreme limits of travel, if necessary.

The crane upon the top of the trestle has a full load traveling speed up to 450 feet per minute, while with a light load, or no load, the speed can be increased to 650 feet per minute. With a maximum load, the hoisting speed reaches 200 or 250 feet per minute, with something of an increase at lighter loads. The travel of the trolley longitudinally of the crane, or transversely of the trestle, varies from 400 to 800 feet per minute, depending upon the load.

The side cantilever cranes are capable of moving along the length of the trolley at the rate of 50 feet per minute. The traveling cranes, mounted upon these cantilevers, are capable of a speed of 20 feet per minute on the full load, the span between centers of rails being 20 feet. The hoisting speed light is 16 feet per minute, and 10 feet per minute with a full load.

There is an operator's house in the frame of each cantilever crane. From this house one man controls all the operations of the machine except that of running the trolley upon the traveling cranes, this being done from below, where the work is carried on and the loads used. The hoist can also be operated from below, as well as from the upper house, this being a great advantage in connection with riveting work.



LARGE NEW CRANE IN SHIPYARD OF HARLAND AND WOLFF, BELFAST, IRELAND.

Henry H. Schulze has left the Estimating Department of the Fore River Shipbuilding Company to become Vice-President of the Wolff Metal Company, Cincinnati, Ohio.

George Alexander Ritchie, a well known marine engineer, died May 2d at his home, 359 Fifth street, Brooklyn, in his sixtieth year. He had been connected with the Morgan Steamship Company for over twenty years.

WATER TRANSPORTATION; ITS ECONOMIC IMPORTANCE.*

BY FRANK HAIGH DIXON.

Taken in its broadest sense, the subject is far too large to treat adequately within the space of a brief paper. I shall therefore take the liberty to define its limits, and restrict my discussion to the economic importance of water transportation in the United States at the present time, with perhaps a few ventures into the realm of prophecy as to its future development. It must be recognized at the start that any observations concerning water transportation in general would be quite profitless. This inclusive term must be divided into its parts, and each part treated separately; for each has had its own history and problems in large measure independent of the others. I shall accordingly treat in order of ocean, lake, river and canal transportation.

OCEAN TRANSPORTATION.

With the marvelous development of ocean transportation in recent years the United States has had comparatively little to do. The causes for this are disputed, and have been from time to time the subject of somewhat bitter political controversy, but they are outside the limits of the present discussion. For our purposes, we accept the fact that in 1904 the United States had less than 900,000 tons of shipping engaged in foreign trade, and was far down the list of nations in the size of its merchant marine, being surpassed not only by England, France and Germany, but even by Norway and Italy. Nevertheless, so indispensable is ocean mechanism to the development of foreign trade for which we are now striving with such earnestness, that it will be worth while to notice briefly its present conditions and its problems.

The ocean carrying trade is the long distance trade of the world. It is chiefly international in character, and includes within its control very nearly all the world's foreign commerce. In the United States, fully nineteen-twentieths of the foreign trade is sea-borne. However, from our standpoint, the significant fact about this form of transportation is that the highway is provided free by nature and requires practically no expenditure for maintenance. This is true of no other transportation agency,

*Read before the St. Louis Railway Club, November 10, 1905.

and is the largest factor in making it the cheapest kind of transportation in existence. When we add to this the fact that outside the three-mile limit the ocean highway is absolutely open, and that there is room for all without crowding or interference, we have the fundamental principles out of which grow all the economic problems of ocean traffic.

Ocean commerce is carried in various types of vessels, which may be classed broadly as steamers and sailing vessels. Steamers may be again divided, according to the nature of the business in which they are engaged, into tramps and liners.

Of the world's traffic that goes in ship-load lots, the tramps carry a goodly share. They are commonly operated individually, and are constructed to meet the demand for a cheap, safe and irregular service. Their usual model sacrifices speed to cargo space. The flat bottom of the boat makes it adjustable to various harbor depths, and puts it in readiness to go to any port that the contract calls for. Its comparatively slow speed of nine knots means less labor force, less demand for engine space and coal bunkers, and more room given to money earning cargo. The informality of the tramp adds to its ability to provide a cheap service. It is not obliged to lose time awaiting a scheduled day of departure, or calling at some intermediate port; nor does it have to leave port half empty to fulfil the demands of an advertised sailing time. The exacting passenger troubles it not. It may seek a cargo wherever cargo offers, and is not confined to a prescribed calling list. It may take advantage of seasonal demand in different parts of the world, and thus avoid the economic disadvantage that on no one trade route are there to be found equal quantities of freight moving in both directions. No large office force is needed, and but little is spent in advertising. Ship brokers and steamship agents, by means of the ocean cable, direct the movements of the wanderer. This perfect freedom of movement, added to the desire of the owner to keep his vessel constantly in action, creates a sharp competition in ocean freights, which may vary from day to day, and even from hour to hour. This is intensified by the fact that a tramp, in order to reach a port where valuable cargo is waiting, will often take cheap goods as ballast at less than the cost of carriage rather than use material, such as water and useless sand, from which no revenue at all can be derived. One of the most common of these ballast substitutes is coal, and so important has its use become, that its distribution has been called a by-product of the tramp steamer traffic. The countries whose imports are the most bulky, and in whose ports, therefore, the steamers are in greatest competition for return freights, are those which are found to be large coal exporters. One of the reasons why the United States has not become an important coal exporter in spite of her great supply is that her exports are largely of the bulky order, and any vessel carrying exported coal, would have to return in ballast, thus compelling the coal to pay the cost of the trip both ways. In the kind of traffic which this type of vessel handles, raw materials principally, of which the most important is grain, the problem of monopoly in transportation charges seldom if ever enters.

Line steamers are those which sail on a schedule to regular ports and carry the traffic, including passengers, which is dependent on speedy and certain delivery. This service is much more costly than that of the tramps, for several reasons. In the first place, the vessel must adhere to its schedule. This may mean delay after the vessel is loaded, or departure partly empty. Again, the necessity for a full cargo on a definite day requires large outlay for advertising, a large office force and abundance of warehouse space. In the third place, special and costly types of construction are necessary for special kinds of traffic, such as passenger traffic, and products requiring refrigeration. Finally, high speed necessitates resort to the narrow racing type of construction, which sacrifices cargo space. It means increased coal consumption, a greater crew, more bunker and machinery space, and less space for paying cargo. Machinery at high speed has a higher maintenance cost, and vessels of this class are more liable to accident. The advantage of the liner comes from the fact that its regularity and speed give it a monopoly of passengers, mail and high grade valuable freight upon which it can charge high rates, and it is enabled to mix its cargo as a tramp cannot, thus making best use of both its weight-carrying and space-carrying capacity. Therefore, where traffic between ports is heavy, and more or less dependable, it is to be expected that lines of steamers will appear, and will increase in number, and it is natural to find the finest examples of this kind of service plying between New York and European ports.

A lack of time prevents a detailed discussion of the fascinating history of the mechanical development of the ocean ship from the wooden sailing vessel at the beginning of the nineteenth century to the steel steamship at its close; but a mere mention of the progressive stages may not be without interest. The date commonly given for the introduction of steam is 1833; then comes the substitution of iron for the wooden hull in 1843, the change from paddles to screw propellers about 1850, from simple to compound engines in 1856, from iron to steel hulls in 1879; and in the next decade, from single to twin screws and from compound to triple-expansion engines; and now, because of a conviction on the part of many engineers that reciprocating engines have reached a stage of efficiency which cannot be surpassed, that is, that speed cannot be increased without a more than corresponding cost of operation, experiments are being conducted with the turbine motor. With this mechanical development should be included the improvement of harbors which facilitates the landing of steamers, makes loading easier, and connection with railroads more satisfactory. These improvements comprise longer wharves and drydocks, deeper and broader harbors with straighter entrances, and handling machinery, particularly for loading and unloading bulk cargo, such as grain and ore. The enormous shipments abroad of wheat and cotton, for instance, would have been impossible without the efficient co-operation of steamship and railroad through some effective means of freight transfer.

With the modern steamer, whether tramp or liner, the sailing vessel is unable to compete. Its advantages are cheap construction, free power, very little motor machinery, a maximum of storage space and a small crew. The machinery and coal bunkers of a steamer occupy about one-third of its capacity, in comparison with one-twentieth in the sailing vessel. The crew is three-eighths larger in proportion in the steamer, but the sailer is uncertain, slow, and sometimes fails altogether. It is not surprising, therefore, to find that in spite of its low operating cost, the sailing vessel is disappearing from the ocean with the increase in efficiency of the steamer. During the twenty-five years from 1874 to 1899, the steam tonnage of the world increased 336 percent, while sail tonnage decreased 40 percent, Norway being the only country that held its own, and Norway's sail tonnage has in the five years since declined one-third. In 1903, of the total tonnage afloat, only 27.7 percent was sail. The sailer is still found in the Atlantic-Pacific coasting trade, but the completion of the Panama Canal will probably end its career, as the competition of the sailer around the Cape with the steamer through the canal would seem to be impossible. On other routes which have been the monopoly of the sailer in times gone by, such as that from New York to Australia by way of Good Hope, with a return via Cape Horn, its rights are being invaded by the steam vessel. It will probably continue on the less important routes for a good many years, but its usefulness is limited and its ultimate fate is sealed.

As already noted, the competition of ocean carriers makes the ocean rate situation a very different question from that which arises in inland traffic. An exporter of ship-load lots may charter vessels outright for single voyages or for longer times, the terms depending upon his ability as a bargainer and the supply of

shipping. Where goods are not in full ship-loads, bargaining for each individual shipment is common. Rates may vary not only as between goods of different value, weight and bulk, but even in the case of the same goods if offered at different stages in the loading of a vessel. Freight necessary to complete a full load may be taken below the cost of handling. The situation is still further influenced, as already stated, by the fact that vessels rather than wait too long for a cargo, or depart in ballast, will offer attractive rates to secure a load. The significant facts concerning ocean rates, therefore, are their flexibility, and their rapid and sudden changes, the explanation being found in the presence of almost unrestrained competition.

LAKE TRANSPORTATION.

There are, outside of the Great Lakes, no lakes of sufficient importance from the economic standpoint to demand consideration. We shall, therefore, confine our discussion to this great inland sea. The geographical situation of the Lakes, which touch the richest traffic sections of the United States, invading the agricultural lands and the mining regions of the northwest, and reaching almost into the manufacturing centers of the east, gives them the possibilities of an immense traffic. The shores of Lake Superior are lined with iron and copper docks; Lake Michigan, with Chicago at its base, taps the great corn district of the country; on the south side of Lake Erie is situated the manufacturing city of Cleveland, and at its eastern end is Buffalo, rapidly becoming an iron and steel center because of its strategic position; abundance of transportation facilities bring this lake into close connection with Pittsburgh.

The mechanism of lake transportation consists of steamers and sailing vessels, as on the ocean. A rapid increase in the size of steamers has taken place in recent years, until we now have vessels many of them as large as the ocean tramps. A change in material of construction from wood to steel has accompanied increase in size, in order to provide the increased strength necessarily demanded by the larger vessel operated by steam. Says one writer, "The history of marine architecture does not furnish another instance of so rapid and complete a revolution in material of floating equipment as has taken place on the Great Lakes since 1886." As on the ocean, so on the lakes, the steamers have driven out the sailing vessels, but more rapidly, because of the greater danger to sailing vessels from lake storms, and because good steaming coal being found in the lake ports at a moderate price, the steamers are not obliged to waste cargo space in carrying a large supply of fuel. These vessels, with their great capacity and high speed, are not only ending the usefulness of sailing vessels on the lakes, but are even checking the growth of the towing business, and are likely at no distant day to destroy it altogether.

No description of mechanism would be complete that omitted to mention the instrumentalities at the ports which have increased so enormously the efficiency of lake carriers. The huge docks, with their loading spouts, hoisting machinery, car-dumping machines and ingenious devices of all kinds, have reduced to a minimum the amount of time lost by vessels in port, and as operating expense is nearly as great while vessels are lying alongside, as when in motion, the importance of quick loading and unloading as a means of reducing operating cost becomes apparent.

The characteristics of this lake commerce may be quickly noted. In the first place, it is of enormous volume, the traffic passing through the American and Canadian "Soo" canals in 1904 being 31,546,000 tons, and the total traffic of the lakes being over fifty million tons. This traffic has grown from a paltry 100,000 tons fifty years ago.

In the second place, the traffic is simple in character, its greatest proportion consisting of the products of the extractive industries. Of the eastbound tonnage through the "Soo" in 1904, 98.9 percent consisted of grain, flour, iron ore, and lumber, and of the total west-bound tonnage 84 percent was coal. This makes the problem of providing traffic facilities a comparatively simple one, and opens the way to extensive specialization, which means lower operating cost and a possibility of lower rates. About twenty million tons of iron ore are now carried from the Lake Superior ports each season, nearly two-thirds of the country's total production. The ranges of iron mines are distributed along the south shore of the lake and to the north and west, and the ore, handled with the most approved machinery in the least expensive manner, is hauled mainly to six shipping ports. Much the larger part of the grain and flour is received at Buffalo, the next port in importance being Erie, where a small portion is diverted to the railroads and carried to the South Atlantic ports for export. Rates are lower from Chicago than from Duluth because of greater rail competition, the average rate for 1904 from Duluth being 1.8 cents a bushel, from Chicago 1.6 cents. In 1904, the total grain and flour received at Buffalo, counting four and one-half bushels of wheat as equivalent to one barrel of flour, was 103,000,000 bushels. Some of the other grains shipped by lake exceed in quantity the wheat handled. 39,000,000 bushels of corn were shipped in 1904, almost entirely from Chicago; 32,000,000 bushels of oats and 19,000,000 bushels of barley were handled by water from a large number of ports Buffalo was the destination for almost all the shipments of these three grains. The distribution of lumber is more general than that of any other important product of lake transportation. Of the total shipments in 1904, of 1,758,000,000 feet, Duluth was the only port that shipped over 150,000,000, and eighteen ports contributed large amounts. Coal for the entire section about the upper lakes and the northwest comes from Pennsylvania, West Virginia, Ohio, Indiana and Illinois. The extent to which this business is handled by water depends upon the desire of the railroads for the traffic as expressed in attractive rates. Fully nine-tenths of the anthracite lake shipments are handled through Buffalo, the only other port of any importance being Erie. Lake Erie ports handle bituminous coal, about three-fifths being shipped from the three ports of Ashtabula, Cleveland and Toledo Because of competition for return cargo, coal is taken by Lake Superior ore boats at little if anything above the cost of carriage, while fair rates may be charged on coal to Chicago and Milwaukee, to which fewer boats go. For example, the average hard coal rate for 1904 from Buffalo to Chicago was 43.4 cents per ton, to Duluth, 33.9 cents, the distance being practically the same. The soft coal rate from Ohio ports to Milwaukee in 1904 (none is sent to Chicago) was 47.4 cents per ton, to Duluth 37.1 cents.

The third characteristic of lake commerce is the preponderance of east-bound over west-bound business. Thus the problem of "empties" with which the railroads are compelled to wrestle troubles the lake carrier also, and obliges many vessels to return west in ballast.

In the fourth place, lake commerce is practically all through traffic. A certain amount of port to port traffic takes place on Michigan and Erie, but the most important part of the Michigan local traffic is across the lake and is simply a continuation of the rail journey on car ferries. On Lake Erie, a package and passenger business has developed from Detroit to Cleveland and Buffalo. These local lines formerly competed with railroads, but they are now either owned by or operated in connection with railroad systems, and act as their collectors and distributers. But the main lake movements are of much greater length, originating in the upper lake ports, and terminating beyond the St. Clair River. The average length of carriage of thirty-five million tons of freight in 1903 was 835.6 miles. Eighty-three percent of the east-bound tonnage of Lake Superior went to Lake Erie and beyond, and 95 percent of the west-bound tonnage destined for Lake Superior ports originated on Lakes Erie and Ontario.

Finally, the business of lake transportation is characterized by consolidated control, which is much more effective than on the ocean because of the smaller area, the identity of ownership of railroads, manufacturing plants and lake vessels, and the absence of any large miscellaneous traffic which would attract competition. The smaller fleets, and particularly the towage companies, have been bought up and operated by large companies, but the most striking fact is the entrance into the field on their own account of large industrial interests. Thus, for example, the United States Steel Corporation at the close of 1904, had a fleet of seventy steamers and forty-two barges. They carried 8,400,000 tons of ore, and 730,900 tons of miscellaneous freight, with total gross earnings of $6,765,353. The Standard Oil Company operates its own tank steamers. Six railroad trunk lines have vessels largely for the purpose of distributing coal to the northwest. Vessels are seldom owned now by individuals, for they are too expensive to build, and the risk is too great, but there are enough lines operating independently of the railroads to provoke sharp competition in rates during the eight months of lake navigation.

It has come to be generally acknowledged that, taking the two forms of transportation as they exist today, rail transportation cannot compete with that on the Great Lakes in the matter of cheapness. This may be illustrated by comparing lake rates with those of railroad systems serving in part the same territory. The revenue per ton mile received by the Lake Shore road on 4,610,710,625 ton miles of freight in 1903 was 5.21 mills; by the Nickel Plate on 1,309,956,766 ton miles it was 5.27 mills. In striking contrast with these receipts is the lake rate, which on 28,974,660,408 ton miles of freight passing through the "Soo" was .92 of one mill. It is evident that railroads must have offered other advantages which offset the low lake rate, in order to hold their own as well as they have done. But several facts should be noticed in this connection. In the first place, lake traffic is preponderantly through traffic and the low rate quoted is a through rate. The rate per ton per mile given for the two railroads covers a large amount of local traffic in which cost must necessarily be higher. Again, the railroad figure is made up from the aggregate freight handled, which includes both high and low grade commodities. Lake traffic is almost entirely raw products, and the traffic is so regular and homogeneous that facilities peculiarly adapted to its manipulation can be employed to the best advantage. But of far greater importance is the fact commonly overlooked by those who compare these rival means of transportation, that the right of way is furnished to the lake vessel free of charge.

RIVER TRANSPORTATION.

A discussion of river transportation in the United States compels us to confine ourselves almost exclusively to a sketch of its past, or to prophecy as to its probable future, for it is a fact which appears astonishing in comparison with the attention given to this form of transportation in France or Germany that our river highways are almost absolutely unused at the present time for the carriage of passengers and freight. A glance at the statistics published monthly by the Bureau of Statistics of the Department of Commerce and Labor reveals the fact that few rivers have traffic enough to warrant their inclusion in statistical tables. The mighty Hudson does not appear in the list. It forms a part of the water shipment for traffic on the Erie and Champlain Canals, and has some passenger and package business between New York and Albany, but it has no effect whatever upon railroad rates. The Monongahela as far up as Fairmont, West Virginia, 126 miles, is used extensively for the transportation of coal to Pittsburgh and to points on the Ohio River. During the month of August, 1905, 780,000 tons of freight were handled down stream, of which nearly 94 percent was coal. The up stream freight was 132,575 tons of which sand and gravel constituted 94 percent. Of the total vessels engaged, considerably over half were coal boats, barges and flats. The Great Kanawha River handled during 1904 1,150,000 tons of freight, of which 93 percent was coal. The rivers which extend inland in so many of the southern states are of practically no effect in competition with the railroads. The steamers are small, and irregular in their movements, and because of the risks of navigation on these small streams and the high insurance cost resulting therefrom, the railroads practically control the business.

Turning our attention to the Mississippi and its tributaries, which drain an area of 1,240,000 square miles, or nearly one-third of the territory of the United States, we will inquire what is the present economic importance of this great highway. The total number of vessel arrivals reported at Cairo for the year 1904 was 5,577 of which 1,811, or 32 percent, were steamers, the remainder being classed as boats or barges. These figures indicate a stationary, if not a declining tonnage. The impression gathered from testimony of witnesses before the Industrial Commission is that no increase of any importance has taken place since 1890. This impression is confirmed by tonnage statistics presented in the report of the Commissioner of Navigation, which shows that the tonnage of the entire Mississippi system was 298,892 tons in 1893, and 215,095 tons in 1903.

A few facts may make clear the present importance of the river as a transportation agency in comparison with the railroads. In the year 1904-05, New Orleans received 8 percent of its cotton by the way of the Mississippi; Memphis received 12 percent by this highway and shipped practically none. Of the total freight receipts of St. Louis in 1904, 1.25 percent came by river, including the upper and lower Mississippi, Ohio, Illinois, Missouri, Cumberland and Tennessee. This small percentage was 45,000 tons less than in 1903, and 120,000 tons less than in 1902. Of the total traffic out of St. Louis, .06 percent went by river, and this was nearly 130,000 tons less than in 1903, and 140,000 tons less than in 1902. The insignificance of river traffic at St. Louis appears more striking when a few of the separate commodities commonly handled by Mississippi steamboats are considered. Of the total receipts of cotton at St. Louis in 1903-04, .2 percent came by river, and .04 percent were shipped in this way. Flour, receipts, .6 percent; shipments, .8 percent. Wheat, receipts, 3.4 percent; shipments, .02 percent. Corn, receipts, .2 percent; shipments, .28 percent. Lumber and logs, receipts, 1.6 percent; shipments, .16 percent.

The report of the St. Louis Merchants Exchange for 1904 shows that no export grain was sent to New Orleans by river during the year, and that but five trips by steamboat were made to that port. It is evident, therefore, that the lower Mississippi can no longer be regarded as a serious factor in the transportation problem of the cities along its banks.

The great traffic of the upper Mississippi in the past has been lumber and logs, but this is rapidly declining with the exhaustion of the forests along its upper courses. The mills which used to line the banks of the upper river in great numbers are closing down and plants are being constructed in the northern woods, whence the lumber is being shipped out by rail.

The traffic of the Missouri, never large, has been practically wiped out by railroad competition.

On the Ohio alone does there seem to have been any increase in traffic in recent years, and that is confined almost entirely to the one commodity, coal. Thirty-three percent of the vessels passing Cairo are loaded with this commodity. The coal sent down the Ohio from Pennsylvania and West Virginia is destined mainly for Cincinnati and other Ohio river points, but a large amount traverses the entire 2,200 miles to New Orleans. Fleets of coal barges in tow, carrying 10,000 to 15,000 tons, are made up at Pittsburgh, and when the stage of water is favorable are brought down to Louisville, where they are made up into fleets

of from 35,000 to 40,000 tons, destined for New Orleans. The barges are made of wood. The strongest of them, after discharging their cargo, are towed back to the mines for reloading, but 70 percent of them are constructed as cheaply as possible, and are sold for rough lumber in or near New Orleans. This cheap method of transport makes possible a rate of $1 per ton for the distance of 2,200 miles, or less than half a mill per ton mile, a rate that is superior to railroad competition.

Undoubtedly the early and very rapid development of our railroad systems, and the desire, more urgent in America than anywhere else, for speed in transportation, has had much to do with this neglect of our waterways, but this does not wholly explain the fact that our greatest river lies almost unused. Let us note briefly its traffic history. The first steamboat on the Ohio River was launched at Pittsburgh in 1811, but at first could proceed only down stream, because with its imperfect construction it could not make headway against the rapid current of the Mississippi. It was 1817 before a steamer succeeded in overcoming this difficulty. The invasion of the southwest by the new transportation agency opened up the section to settlement, and led to a prompt utilization of the river for the transportation of cotton, and for the shipment of supplies into the south from the new sections of the west. Steamboats on western rivers increased in number from 20 in 1818 to 1,200 in 1848, and a similar development took place in flat boat tonnage. The effect of this was shown in the development of the cities and towns along the river banks. Louisville grew from 4,000 in 1820 to 43,000 in 1850; St. Louis from 4,900 to 77,000. With the building of the Erie Canal in 1825, the people of the central west bordering on the lakes found a ready access to market, and middle western commodities, which had moved in a southerly direction altogether up to this time, were in part diverted toward the east, building up the city of New York, with its splendid harbor, and encouraging the establishment of ocean lines serving this port. With the opening of the Welland Canal in 1833 another route was provided through Lake Ontario and the St. Lawrence to Montreal and Quebec. The distance to the Gulf ports and the decided inferiority of any southern port to that of New York, worked in favor of the eastward movement of trade. However, the river continued to occupy an important place until the railroad reached the middle west in the fifties. From that time it was doomed, for the railroads, with their constant improvements in mechanism and in administration, were able to offer steadily lower rates, and to accentuate the movement which the lakes and canal had begun. The ocean lines improved their service to keep pace with railroad development, and made the monopoly of the Atlantic ports secure. It is only within a decade that this monopoly has been seriously questioned, and this has been brought about, not by the development of river traffic, but by the growth and perfection of railroad systems leading to southern ports, and opening up the middle and southwest to the foreign market through Galveston, Port Arthur and New Orleans. The inadequacy of steamship facilities at these ports, which has handicapped this section, can be accounted for partly by lack of return freights, or imports. In short, aside from the turn of fortune which gave the eastern ports their start, and the advantage which this priority of development gave them in crystallizing a habit once formed, the greater industrial development of the eastern states contributed largely to the retention and strengthening of this eastward movement of commodities by offering a market for imports, and providing the ocean steamship with return freights.

There is a probability that the opening of the Panama Canal will so develop the south industrially that the river will again become an important commercial highway. It is possible, as suggested by the Isthmian Canal Commission, that with the development of our coal market in South America and with an increased demand for coal in the Gulf, West Indian and Central American stations to supply the steamers engaged in commerce through the canal, a special type of steel barge may be constructed to carry coal from Pittsburgh down the Mississippi to West Indian and Gulf ports, and even through the canal to South America.

It must be borne in mind, however, that such improvements as are necessary and desirable in the Mississippi and its tributaries will represent an enormous investment of capital, and although this work, if done at all, should be done by the general government, and although the people of the country will contribute cheerfully to this great work through taxation if the desirability of it is demonstrated, nevertheless such a burden should not be thoughtlessly imposed upon the American people, and the work should not be undertaken until its projectors, after a careful estimate of all the factors in the case, are convinced that the results will be worth the cost.

CANAL TRANSPORTATION.

In the discussion of this phase of water carriage, we shall exclude from consideration such canals as that at St. Mary's Falls, connecting Lakes Superior and Huron, and the Louisville and Portland Canal around the falls of the Ohio at Louisville. These are but devices for making lake and river transportation more effective, and are clearly justifiable economically if they are warranted by the commerce on the waterways which they are designed to improve. Enough for our purpose also has been said of the Panama Canal in our discussion of ocean commerce. I shall therefore confine myself to inland canals, which have an independent existence, and are not merely intended to render more serviceable already existing bodies of water. Canal building began on an extensive scale before the advent of railroads, but many of them probably would never have been built had railroads first appeared.

The canals of the United States still used for commercial purposes are stated by the *World Almanac* for 1905 as thirty-eight in number, with an aggregate length of 2,470 miles, and a construction and improvement cost of over $200,000,000. It is needless to say that the term "commercial purpose" has been generously interpreted, and that there is included in the list every canal which is in sufficient repair to permit the occasional passage of a flat boat drawn by the patient mule which plods along the bank. The only canals whose business is sufficiently regular to warrant the inclusion of their traffic in the government's monthly reports are the Chesapeake and Delaware, connecting Chesapeake and Delaware Bays, with an annual traffic of about 700,000 tons, largely lumber; the Chesapeake and Ohio from Cumberland to Georgetown, owned by the state of Maryland, transporting coal almost exclusively, the amount depending upon the extent of the congestion of paralleling railroads; and the New York canals. Of the latter, the only one of importance besides the Erie is the Champlain Canal, connecting the southern waters of Lake Champlain with the Hudson. This canal handled in 1903 only about 800,000 tons of freight.

In view of its position historically and of the movement now under way for its enlargement, the Erie Canal demands more detailed treatment. The opening of this canal in 1825, as already noted, created an east and west waterway of the first importance for the industrial interests of the time, and for the next twenty-five years was the main highway of traffic between the middle west and the Atlantic coast. Proving inadequate to the demands of traffic, it was enlarged in 1862, and deepened from four feet to seven, where it has since in large part remained, accommodating vessels of 240 tons with a capacity of 8,000 bushels of wheat. All tolls were abolished in 1882, and the canal has since been maintained out of the treasury of the state.

The Erie Canal has not kept pace with the demands of modern business. The rapid development in efficiency of the railroads of the state, which can carry a maximum of 90,000 bushels of

grain in a single train load, and the enormous demands of commerce through the Buffalo gateway, have left the canal far in the rear. It still employs horse and mule power; electricity has been tried only experimentally. Its total tonnage has been gradually declining for many years. The greatest tonnage ever secured was in 1880 when 4,608,000 tons were handled. In 1903, the total was 2,414,000 tons, which was about the same amount as in the fifties, before the canal was enlarged. Of the total tonnage of freight carried by railroads and canals in New York, the canal tonnage has fallen with almost unwavering regularity from 68.9 percent in 1859, to 5 percent in 1903. In 1898, the New York Central and Erie railroads carried 46,000,000 tons of freight, as compared with 2,300,000 tons on the Erie Canal. This represented the capacity of the canal, and was allowed to the waterway because the railroads did not care for it. The bulk of its traffic consists of lumber, ice, stone, lime and coal. Less than 10 percent in 1899, and less than 8 percent in 1900, of the flour and grain received at New York came by this route. According to the testimony of the chairman of the railroad grain committee at Buffalo before the Interstate Commerce Commission in 1900, the canal is ineffective under present conditions, such as size and speed of boats, either in carrying traffic or in making rates, and canal rates are now made in accordance with railroad rates.

The construction of a ship canal has been suggested. This has been dismissed as impracticable, at least for the present, because of its enormous cost and doubtful expediency. The proposition to enlarge the canal to a depth of twenty-one feet to accommodate lake vessels has been rejected, first because of the loss in investment that would result from the fact that vessels built to run fifteen or twenty miles an hour would be reduced to a speed of five miles an hour for a distance of nearly four hundred miles through the canal; and second, because lake steamers could not run alongside ocean vessels as the canal barges can do, but would require lighters, thus greatly adding to the terminal expense. The people of New York State have therefore authorized the Legislature to expend $101,000,000 in an enlargement of the Erie and other canals to a depth of twelve feet, carrying boats of cargo capacity of 1,000 tons or 33,000 bushels of wheat, four times the present size. It is expected that better methods of propulsion can be employed, either electricity or steam, and that a canal boat, with three convoys, can travel at an average of four miles per hour night and day, thus reducing the time between Buffalo and New York from twelve days to five and one-quarter days. The advantages expected from such enlargement are a development of local business by the establishment of industries along its banks, a growth of through business in grain and lumber, in iron and steel products eastward and in coal westward, and a regulation of rail rates through the potential capacities of the new waterway. The estimated capacity of the new canal is in excess of 20,000,000 tons per annum, or about 30 percent of the total present freight traffic of New York state. The project, although approved by a referendum vote, has been delayed by legal difficulties, and the work has not yet been undertaken.

Supporters of the canal building policy are accustomed to refer to the results attained in European countries, particularly in Germany and France. It is worth while to pause over this matter long enough to show that the experience of these countries has little in it that can be properly applied to American conditions. In the first place, the great increase in traffic on the waterways of Germany and France has been not on canals proper, but on the great natural waterways, the Elbe, Oder, Spree, Rhine, Main, Seine and Marne, and enormous amounts of money have been spent in improving these rivers so that the cities far up their courses might be converted practically into ocean ports. These rivers are so well situated, and are navigable for such long distances, and drain such immense areas of country, that they become commercially available for widely scattered industrial interests. Of the total of 8,737 miles of waterway available for traffic in Germany a few years ago, 5,776 miles were rivers, and 1,451 miles were canalized rivers, leaving 1,510 miles for canals proper.

In the next place, it is to be observed that in both France and Germany the traffic on the canals, with very few exceptions, pays no tolls. Canal charges cover nothing but the actual cost of carriage. The waterway is not only constructed and improved by the state, but the annual expenditures for dredging, lighting, superintendence, and the maintenance of inland harbors, is a charge upon the treasury. Again it is to be noticed that in Germany and France both rail and water transportation are under direct control of the state. In Germany the railroads are owned, in France their dividends are guaranteed, by the government. In neither country are they permitted to put into force competitive tariffs. In Germany, the waterways have not developed new traffic so much as they have absorbed traffic largely handled by railroads in other countries; and the railroads, instead of developing through traffic at competitive rates, are being reduced to their earlier position as mere feeders of water transport. An active water development policy accompanied by railroad restraints has suited the German Government, and has proved profitable to the treasury in bringing in an enormous net revenue from short-haul railroad business at high rates. These conditions are set forth by witnesses whose authority is unquestioned, such as Ulrich in Germany and Colson in France. We must certainly conclude that it would be absurd to infer from the situation in these two countries that canal carriage is necessarily cheaper than railroad carriage. In fact, Colson goes so far as to assert that in most cases in France the net cost of transport is appreciably higher by water than by rail.

Mr. W. M. Acworth, of England, than whom there is no keener or better informed critic of transportation conditions now writing in the English language, in a recent article on British canals, asserts that the alleged economic superiority of canals does not in fact exist. Among the distinct disadvantages under which canals suffer Mr. Ackworth mentions the following: If volume overtakes capacity, the canal cannot be gradually improved so conveniently or so cheaply as the railroads; although cheaper to maintain, it is often out of use, through summer droughts, winter ice and repairs of locks and banks under water; railroads by charging high rates on high grade goods, are able to give a very low rate on low grade commodities, whereas in canal operation freight traffic must bear all the expense, unaided by supplementary revenue from passengers, mail, and parcel traffic which the railroads enjoy; slow merchandise, for which alone canals are fitted, is becoming of relatively less importance every year in the sum total of traffic handled; the railroads can go anywhere, can offer a rapid and certain service, and can provide adequate switching and terminal facilities; whereas canals, always slow and uncertain, are distinctly limited in their provision of terminals, and are confined largely to level country by reason of the fact that canal efficiency rapidly decreases when frequent changes of level are necessary.

What then in view of all these facts, must be our conclusion as to the proper policy for the United States to pursue with reference to the improvement of its waterways? I would not have you infer from the facts presented that I occupy a position of determined hostility to the improvement of our rivers and to the construction and enlargement of our canals. My plea would be not for an abandonment of all forms of water transportation, but rather for a thorough and conscientious consideration of all possible factors in the case before an improvement is decided upon. Two considerations should above all others be kept in mind in the determination of the feasibility of any project; first, the very positive limitations to the efficiency of rivers and canals as transportation agencies because of their lack of flexibility and the natural disabilities under which they suffer;

and second, that water transportation is not necessarily cheap simply because the government constructs and maintains the channel. Nothing could be more delusive than the assertion so frequently made, which is found in the opening pages of the report of the New York Committee on Canals of 1899, that water transportation is inherently cheaper than rail transportation. Such an assertion is true only of ocean transportation, and possibly also of large bodies of water like the lakes, although this last is doubtful.

Accident to the Steamship Louise.

Leaving Malolaks, Finland, for Hull, last July, with a large cargo of logs, the steamship *Louise*, of Hamburg, carried also a heavy deck cargo, amounting to about 800 tons of timber. She had hardly left Malolaks when the port bulwark stanchions gave way under the pressure of the deck cargo, and half of the cargo on that side of the ship was lost overboard. She had only just

DECK VIEW OF LOUISE, SHOWING DAMAGE.

righted herself when the starboard stanchions also gave way, and nearly the entire balance of the deck load was lost. In thus shifting, the cargo bent the bulwarks back upon themselves, as shown in the illustration, and also broke the foremast stays, thus causing the mast to double and collapse as indicated. Having landed the remainder of the deck cargo, the ship proceeded on her voyage, and was later placed for repair in the dry dock of the Earles Shipbuilding Company, at Hull.

VIEW SHOWING BULWARKS BENT OUTBOARD.
Photographs by James Fisher, Hull.

The *Louise* is a steel screw steamer of 2,143 tons net. Her length is 350 feet, beam 48 feet, and draft 16 feet 4 inches. She was built in 1898 by Messrs. Bartram & Sons, of Sunderland, England, and is propelled by a triple-expansion engine with cylinders measuring 24, 39½, and 65 inches in diameter, with a common stroke of 42 inches.

MOTOR BOATS, XIII.

BY DR. WILLIAM F. DURAND.

POWER AND SPEED.

There is no problem in connection with the motor boat so hedged about with difficulty and uncertainty as that concerned with the relation between the characteristics of the boat and the power for a given speed, or the speed which may be expected for a proposed power. This is due primarily to the obscure character of the relation between the factors on which the resistance of a boat depends, and on the fact that no general formula or definite relation can be derived by purely theoretical methods. It results that experiment and experience are the only sources of final and definite information, and for every boat which marks a new departure the experiment must be carried to a conclusion before definite assurance can be gained regarding these relations. On the other hand, every boat which is built, and regarding which definite results are available, becomes a basis for an indefinite series of boats of similar geometrical form, and driven at speeds related to that of the type boat by a simple geometrical factor. It is true that if the boats differ greatly in size the relation given by this law of comparison is less trustworthy. If, however, the difference in size is moderate or small, and the geometrical forms are similar, then the results of the one may be used with confidence for the design of the other.

In approaching the subject in somewhat further detail, we may first note very briefly the character of boat resistance. It seems natural in attempting to classify or analyze such resistance to proceed according to the manifest results. These may be divided into two general classes, as follows:

(1) A thin film of water composed of small eddies lying near the skin of the boat and surrounding the wetted surface somewhat like a blanket or sheath.

(2) General effects manifested in the form of waves and surface disturbances.

Each of these requires the expenditure of energy for maintenance in its position relative to the boat, and this means the manifestation of a resistance which must be overcome in order to maintain steady motion of boat relative to water. The sheath of eddy water is caused by forces similar to friction, and acting between the surface of the boat and the water. This part of the resistance is usually called the frictional or skin resistance. The part of the resistance due to the maintenance of systems of waves and surface disturbances is usually called the wave making or residual resistance.

At low speeds the skin resistance forms the principal part of the total, while the wave making resistance is comparatively of small importance. As the speed increases, however, the wave making resistance rapidly increases in relative importance. At moderately high speeds it will form one-half, and at extreme speeds more than one-half, he total resistance. It thus appears, as previously noted, that at low speeds the form of the boat should be designed with some reference to the reduction of surface, and hence of skin resistance; while at high and extreme speeds the form must be chosen with special reference to the reduction of waves and surface disturbances.

The skin resistance increases with the speed by an index somewhat less than 2. That is, this part of the resistance varies somewhat more slowly than as the square of the speed.

The wave making resistance varies with the speed according to a somewhat variable index, found usually between 3 and 5. It results that the total resistance at moderate speeds, when the wave making part is small, will vary with an index not far from 2, while as the speed increases, not only does the resistance itself rapidly increase, but also the average index according to which it varies with the speed.

Returning now to the main problem of power and speed, it must be understood that the practical rules and methods which

are given in the present chapter represent the results of experience on craft of the general motor boat type, as regards form and size, and that the basis for the use of such rules and methods is therefore practical rather than theoretical. On the other hand, it must be realized that no method or formula can be applied to the treatment of such questions without a considerable infusion of judgment, based preferably on experience with problems of this character.

The two questions which arise in this connection are as follows:

(1) What power will be required for a proposed speed?

(2) What speed may be expected with a proposed power?

The one problem is, of course, the inverse of the other, and the solution of either carries with it that of the other.

We shall give two methods for the treatment of these problems, the first based on the so-called law of comparison, and intended for the application of the known results with a given boat to the design of another of similar geometrical form but of different size; and the second by the use of a formula direct, and independent of results drawn from other boats, except in so far as such results are used as a guide in selecting the value of the arbitrary "constant" in the formula.

Taking the law of comparison first, it should be noted that this law, strictly taken, is intended to apply only to the residual or wave making resistance, and that it can be applied only approximately to the skin resistance. This lack of application to the skin resistance is, however, only partial, and when applied to the problem of powering as a whole the results are at least as good as may be found by any other quick and practical method, such as is desired for the purposes of these pages.

It must be clearly understood that the law of comparison is intended to relate the power for a boat A at a speed v_1 to the power required for a boat B of similar form and at a speed v_2.

We must first define what is implied by the word similar. Absolute similarity implies two or more boats made, so to speak, all from the same drawings, and differing only in scale. Such boats would possess absolutely identical geometrical characteristics and coefficients throughout, and would fulfil the full content of the term similar. On the other hand, substantial similarity will be insured if the proportions between length, beam and draft do not differ sensibly between the two boats, and if the general form characteristics and coefficients as discussed in the chapter on design are of closely similar values. In general it may be said that the more closely the two boats approach to full geometrical similarity the more reliable will be the results of the application of the law of comparison; while as the two forms under consideration depart more and more widely from such complete similarity, the less trustworthy will be the results indicated by the application of this law.

We must next relate the speeds v_1 and v_2. These are said to "correspond" or to be "corresponding speeds," and are defined by the following simple proportion:

Let L_1 and L_2 denote the lengths of the two boats. Then we have:—

$$v_2 : v_1 :: \sqrt{L_2} : \sqrt{L_1}$$

$$\text{or } v_2 = v_1 \sqrt{\frac{L_2}{L_1}}$$

In words we may say that corresponding speeds are proportional to the square roots of the lengths. A few illustrative examples will make this clear:

Boat A is 36 feet long, and boat B, similar in form, is 25 feet long. The speed of A is 12 miles per hour, what is the "corresponding speed" for B?

From the formula we have:

$$v_2 = 12 \sqrt{\frac{25}{36}} = 12 \times \frac{5}{6} = 10 \text{ miles per hour.}$$

Boat A is 30 feet long, and boat B, similar in form, is 50 feet long. The speed of A is 18 miles per hour, what is the "corresponding speed" for B?

From the formula we have:

$$v_2 = 18 \sqrt{\frac{50}{30}} = 18 \times 1.29 = 23.22 \text{ miles per hour.}$$

We may now state the law of comparison for power as follows:

The horsepower required to give corresponding speeds in two boats of similar geometrical form will be in the direct ratio of either:—

(1) The seven-sixths power of the weights or displacements, or

(2) The seven-halves power of the lengths.

Thus, denoting the powers in the two cases by H_1 and H_2, and the weights or displacements by W_1 and W_2, we have algebraically:

$$H_2 : H_1 :: W_2^{\frac{7}{6}} : W_1^{\frac{7}{6}}$$

$$\text{or } H_2 = H_1 \times \left(\frac{W_2}{W_1}\right)^{\frac{7}{6}}$$

$$\text{Or, again: } H_2 : H_1 :: L_2^{\frac{7}{2}} : L_1^{\frac{7}{2}}$$

$$\text{or } H_2 = H_1 \times \left(\frac{L_2}{L_1}\right)^{\frac{7}{2}}$$

We may also indicate the operations of these formulas by the following step by step rules:

(1) Divide the displacement of the proposed boat by that of the type or given boat. (Both displacements must be expressed in terms of the same unit, which may be either tons or pounds.)

(2) Find the value of the seven-sixths power of this ratio. This may be done as follows: (a) Take the cube root of the ratio. (b) Take the square root of the result found in (a). (c) Multiply the original ratio by the result found in (b), and the product will be the seven-sixths power desired. The square and cube roots will naturally be determined by the use of tables, such as those found in any of the engineering hand books.

(3) Multiply the power required by boat A at speed v_1 by the result found in (2). The product will give the power required for boat B at speed v_2.

Or, otherwise, using the length ratio:—

(1) Divide the length of the proposed boat by that of the type boat.

(2) Find the seven-halves power of this ratio. This may be done as follows: (a) Find the cube of the ratio. (b) Find the square root of the ratio. (c) Multiply the result found in (a) by that in (b), and the product will be the seven-halves power desired.

(3) Multiply the power required by boat A at speed v_1 by the result found in (2). The product will give the power required for boat B at speed v_2.

A few illustrative examples may now be given.

(1) Boat A is 30 feet long, with a displacement of 8,000 pounds, and is found to make 12 miles per hour with 20 horsepower. What information can be drawn from these results regarding a boat of similar form and 45 feet long, with a displacement of 27,000 pounds?

We have first:

$$v_2 = 12 \sqrt{\frac{45}{30}} = 12 \times 1.22 = 14.64$$

$$\text{Then } H_2 = H_1 \times \left(\frac{27.000}{8.000}\right)^{\frac{7}{6}} = H_1 \times (3.375)^{\frac{7}{6}}$$

$$\text{Now } (3.375)^{\frac{1}{3}} = 1.50$$

$$\text{and } (1.50)^{\frac{1}{2}} = 1.22$$

$$\text{and } 3.375 \times 1.22 = 4.12$$

$$\text{Then } H_2 = 20 \times 4.12 = 82.4$$

We therefore conclude that the larger boat, with a length of 45 feet and a displacement of 27,000 pounds, at a speed of 14.64 miles per hour, would require 82.4 horsepower. It should be noted in particular that this method gives us no indication as

to how much power would be required by the larger boat at the *same* speed as the smaller, but only at the higher or *corresponding* speed.

(2) Suppose boat A is 30 feet long, as before, but with a displacement of 3,000 pounds, and with a speed of 21 miles on 45 horsepower. What can be inferred regarding a similar boat 24 feet in length?

In this case we shall have:—

$$W_2 = W_1 \times \left(\frac{24}{30}\right)^3 = 3{,}000 \times (.8)^3 = 1{,}536 \text{ pounds.}$$

$$v_2 = v_1 \times \left(\frac{24}{30}\right)^{\frac{1}{2}} = 21 \times (.8)^{\frac{1}{2}} = 18.77 \text{ miles per hour.}$$

$$H_2 = H_1 \times \left(\frac{24}{30}\right)^{\frac{7}{2}} = 45 \times (.8)^{\frac{7}{2}}$$

$$(.8)^3 = .512$$

$$(.8)^{\frac{1}{2}} = .894$$

$$.512 \times .894 = .458$$

$$H_2 = 45 \times .458 = 20.6 \text{ horsepower.}$$

We therefore infer that the smaller boat, with a displacement of 1,536 pounds, would show a speed of about 18.77 miles per hour, on 20.6 horsepower.

(3) Again, suppose boat A as in (2), and that we propose a boat B approximately similar, with a length of 36 feet, and a displacement of 5,000 pounds.

We then have:

$$v_2 = 21 \times \left(\frac{36}{30}\right)^{\frac{1}{2}} = 23.1 \text{ miles per hour.}$$

$$H_2 = 45 \times \left(\frac{5{,}000}{3{,}000}\right)^{\frac{7}{2}} = 45 \times (1.67)^{\frac{7}{2}}$$

$$(1.67)^{\frac{1}{2}} = 1.185$$

$$(1.185)^{\frac{7}{2}} = 1.09$$

$$1.09 \times 1.67 = 1.82$$

$$H_2 = 45 \times 1.82 = 81.9 \text{ horsepower.}$$

We may next turn to the method of powering by the use of a formula direct. For this purpose we shall make use of the so called Admiralty Coefficient formula, in the following form:

$$H = \frac{A\,B}{K}$$

where: H = horsepower required,
A = factor taken from table I,
B = factor taken from table II,
K = factor to be selected by judgment as discussed below, and usually found between 200 and 500.

It may be noted that the values of A are found by taking the two-thirds power of the displacement in pounds, and dividing by 100. That is, $A = (\text{displacement})^{\frac{2}{3}} \div 100$. To find A accurately for values lying between those given in the table we therefore proceed as follows: (1) Take the cube root of the displacement. (2) Square the result found in (1). (3) Divide the result in (2) by 100 and the quotient will be the value of A. For most cases, however, the value of A may be taken with sufficient accuracy from the table.

Likewise, the values of B are the cubes of the speeds in miles per hour, and thus other or intermediate values may be found.

The values of K correspond to those of the Admiralty coefficient, and are in fact the numerical values of this coefficient, multiplied by 2.62 in order to reduce them to the units employed in the present formula. The value to be taken in any individual case must be based on judgment regarding the mutual influence of the three items, length, speed, form. Other things being equal, the value will be greater as the length is greater, as the speed is lower, and as the form is finer; and the value will be less under respectively opposite conditions, that is, as the length is less, as the speed is higher, and as the form is less fine. Somewhat otherwise, the value will generally be less as the ratio of the square of the speed to the length is greater, and as the ratio of beam to length, or the form coefficients are greater, and the value will be greater under opposite conditions. A short, wide, full form at relatively high speed will therefore require the lowest values of K, while a long, narrow, fine form at moderate speed will permit of the higher values. This means that the short full form at high speed will require relatively excessive power, and the long fine form at moderate speed will require relatively moderate power, each in relation to the cube of the speed. All this is, of course, in accord with the indications of common sense as applied to such problems.

TABLE I.—VALUES OF A.

Displacement	A	Displacement	A	Displacement	A
500	0.63	8,000	4.00	17,000	6.61
1,000	1.00	9,000	4.33	18,000	6.87
1,500	1.31	10,000	4.64	19,000	7.13
2,000	1.59	11,000	4.94	20,000	7.37
3,000	2.09	12,000	5.24	21,000	7.61
4,000	2.52	13,000	5.53	22,000	7.85
5,000	2.92	14,000	5.81	23,000	8.09
6,000	3.30	15,000	6.08	24,000	8.32
7,000	3.66	16,000	6.35	25,000	8.55

The question of what is a speed relatively high or low still remains. This will depend on length and form. For medium fineness of form speeds in excess of 1.2 times the square root of the length in feet will be relatively high, and to a degree increasing with the increase of speed. For very fine forms the limit beyond which the speed must be considered relatively high is pushed somewhat farther along—perhaps to 1.3 or 1.4 times the square root of the length in feet. In all cases, it should be remembered, speeds are here considered as measured in miles per hour.

TABLE II.—VALUES OF B.

Speed, Miles	B	Speed, Miles	B
5.0	125	5.5	166
6.0	216	6.5	275
7.0	343	7.5	422
8.0	512	8.5	614
9.0	729	9.5	857
10.0	1,000	10.5	1,158
11.0	1,331	11.5	1,521
12.0	1,728	12.5	1,953
13.0	2,197	13.5	2,460
14.0	2,744	14.5	3,049
15.0	3,375	15.5	3,724
16.0	4,096	16.5	4,492
17.0	4,913	17.5	5,359
18.0	5,832	18.5	6,332
19.0	6,859	19.5	7,415
20.0	8,000	20.5	8,615
21.0	9,261	21.5	9,938
22.0	10,648	22.5	11,391
23.0	12,167	23.5	12,978
24.0	13,824	24.5	14,706
25.0	15,625	25.5	16,581
26.0	17,576	26.5	18,610
27.0	19,683	27.5	20,797
28.0	21,952	28.5	23,149

Thus for a boat 25 feet in length, and of medium fineness of form, 6 miles per hour will not be an excessive speed, and for such or lower speeds values of K from 350 to 450 might be safely used. If the form is very fine, then no serious increase of the power relative to the cube of the speed would be looked for below perhaps 7 miles per hour, and for equal speeds somewhat larger values of K would be indicated as compared with the preceding case. On the other hand, as the speed rises above 6 miles with medium fineness of form, the power will increase more rapidly than the cube of the speed, and the values of K must be correspondingly decreased to their lower range.

The same will be true for the finer form, though not to the same degree. Thus for a speed of 10 miles per hour with medium form a coefficient of 250 or 275 might be suitable, while with fine form it might be increased to 300 or over.

For racing craft of specially fine form, of length 30 to 40 feet or thereabouts, and at extreme speeds lying between 20 and 30 miles per hour, specially large values of the coefficient have been realized in practice, indicating possibly a decrease of actual displacement and wetted surface at these extreme speeds, due to lifting of the boat, and in any event a relatively low value of the horsepower required, compared with the indications drawn from boats with somewhat fuller form and at lower speeds. Thus, in several cases of such craft, the values of K as determined by test lie between 350 and 550.

It will be seen in general that so far as the relation of length to square of the speed is concerned, motor boats as a class are all driven at relatively high speeds. Thus taking 50 feet in length as near the upper limit of the motor boat class, the rule given above indicates that speeds above 8.5 to 10 miles will be relatively high for that length, and for everything shorter. In fact any motor boat not driven at a speed higher than 1.2 or 1.3 times the square root of the length in feet would be rated distinctly slow as a boat.

It results therefore that with motor boats as a class the speed is high relative to the length, the power is high relative to the cube of the speed, and the values of K must be taken correspondingly low in consequence. The question of chief practical importance concerns the extent to which this lowering of the value of K may be offset by fineness of form, and in particular to what extent extreme fineness combined with extreme speed may carry the case into a set of conditions justifying the use of relatively large values of K. Experience indicates that in most cases fineness of form does exercise a very important influence on the permissible value of K, and it is with the estimate of this influence that the judgment of the designer must be chiefly concerned. Experience also indicates, as noted above, that excessive fineness combined with extreme speed (especially with forms which naturally tend to lift at such speeds) may give conditions relatively economical for propulsion, and permitting the use of the higher range of values for K.

In this connection mention may be made of the motor boat *Napier II*, constructed in England for the purpose of demonstrating the possibilities of the skimming boat. The bottom is practically flat, and the lines are so adjusted that the boat tends to rise and run at an immersion continuously decreasing as the speed is increased. The results obtained by this boat seem to meet expectations in so far as the relation between speed and power is concerned. The boat, which has a length of 40 feet and a displacement of 7,170 pounds, reached a speed of about 30 miles per hour on 150 horsepower, indicating a value of 665 for the constant K as based on the original displacement. This value in itself indicates a marked decrease in displacement at these high speeds, a condition indicated also by observations on the boat itself under running conditions. It should be noted that, while such possibilities are plainly indicated for very high speeds, they must be purchased at some sacrifice of seaworthiness and weatherly qualities in rough water. The form of the bottom of this craft is such as to subject the boat to severe pounding in a seaway, and the entire design is essentially suited for smooth water conditions only. It may be concluded that, while in the average motor boat some advantage may be realized by the utilization of this principle, yet for the boat intended for average conditions of wind and weather, it can be applied only in small measure; and if stability and weatherly qualities in a sea way are desired, the boat must not be expected to run under conditions which will in marked degree decrease the immersion or the displacement.

We may now turn to a series of examples intended to illustrate the use of the above formula.

(1) Given length = 36 feet, displacement = 12,000 pounds, speed 9 miles per hour. This is an illustration of a boat of fairly large size at moderate speed and of medium fineness of form. The speed, while moderate for a boat of this character, is still somewhat high compared with the length, as indicated by the rules given above, and we must therefore choose a moderate value of the factor K—perhaps from 250 to 300. We have then $A = 5.24$, $B = 729$ and $H = 5.24 \times 729 \div 250 = 15$. If we use $K = 300$, we find similarly $H = 12$. Hence we conclude that from 12 to 15 horsepower should serve to fulfil the conditions as specified.

(2) Given length = 33 feet, displacement = 3,600 pounds, speed 15 miles per hour. Assume fine lines and general conditions favorable to high speed. In such case we may take $K = 300$. We have then $A = 2.35$, $B = 3,375$ and $H = 2.35 \times 3,375 \div 300 = 26$.

(3) Given length = 24 feet, displacement = 4,800 pounds, speed 7 miles. This is an example of a full form, slow speed, family runabout. The conditions indicate a value of K not much exceeding 250.

We have then $A = 2.85$, $B = 343$ and $H = 2.85 \times 343 \div 250 = 3.91$ or say 4 horsepower.

(4) Suppose we try to drive the boat of (3) at 8.5 miles. We should then reduce K to something like 200, and we have $B = 614$ and $H = 2.85 \times 614 \div 200 = 8.75$ horsepower.

(5) Given length = 56 feet, displacement = 12,000 pounds, speed 25 miles. Assume fine lines and all conditions favorable to high speed. In such case we shall take $K = 350$. We have then $A = 5.24$, $B = 15,625$ and $H = 5.24 \times 15,625 \div 350 = 234$.

(6) Given length = 40 feet, displacement = 5,000 pounds, speed = 28 miles. Assume the utmost refinement with reference to high speeds. Under such conditions and at such a speed we shall be justified in taking $K = 500$. We have then $A = 2.92$, $B = 21,952$ and $H = 2.92 \times 21,952 \div 500 = 128$.

(7) Given length = 41 feet, displacement = 3,300 pounds, speed 26 miles. Assume conditions the same as in (6) and take the same value of K. Then we have $A = 2.22$, $B = 17,576$ and $H = 2.22 \times 17,576 \div 500 = 77$.

In some cases it is desired to make a rough estimate of the power, based simply on the dimensions, mean draft and speed, and without definite knowledge of the displacement. In such case it will be necessary to assume a value of the block coefficient as described in the chapter on the design of form, and using this with dimensions, the displacement may be found as indicated by the following example:

Given length 32 feet, beam 5 feet, mean draft 2 feet, speed 12 miles. Assuming that the form is fairly well fined away we may take the block coefficient at 0.45, and we find therefore for salt water: displacement = $32 \times 5 \times 2 \times .45 \times 64 = 9,216$ pounds.

In connection with the general problem of speed and power it will be convenient to note here the relation between the power of a gasoline engine and the characteristics on which it depends. It will be remembered that the conditions differ from those with the steam engine on account of the difficulty of measuring the indicated horsepower of an internal combustion engine of the type, size and revolutions commonly met with in this field of service. Instead of the indicated horsepower, gasoline engines are usually rated by brake or delivered horsepower, representing the power actually delivered to the propeller shaft. In the discussion of such engines it often becomes convenient, furthermore, to refer to the rated power of the engine, based on the dimensions and revolutions per minute. Such power is computed by an arbitrary formula, of which several have been proposed. The simplest of such is in the form:

$$H = \frac{N A L}{C}$$

where: N = revolutions per minute,

A = the sum of the areas of all pistons, expressed in square inches.

L = length of stroke in feet.

C = a constant selected according to type of engine and general conditions of operation. For a four-cycle engine and good conditions C may be taken from 1,000 to 1,200. For a two-cycle engine and good conditions C may be taken from 700 to 800. According to the formula of the American Power Boat Association, C = 1,000 for four-cycle engines and 750 for two-cycle engines.

A South American River Steamer.

An interesting vessel, the paddle steamer *Asuncion*, has been launched on the Clyde by William Denny and Brothers from the Leven shipyard, Dumbarton, to the order of Señor Don Nicholas Mihanovich of Buenos Ayres. She is of the following dimensions:—Length 200 feet; breadth (molded) 30 feet; depth (molded) 9 feet.

The vessel is constructed of mild steel, and has been specially designed for South American river service. Accommodation is provided for 80 first-class passengers, in large well ventilated rooms on the main and promenade decks; and for a number of third-class passengers on the fore end of the main deck. The dining room is a large apartment on the promenade deck, fitted with every modern appliance for the comfort and convenience of the passengers. The vessel is fitted throughout with electric light, installed by the builders. The steam steering gear is controlled from the flying bridge; and a steam windlass is fitted forward for working the anchors and warping the ship. The *Asuncion* being a mail and passenger vessel, the amount of cargo that can be carried is necessarily limited, but cranes are provided for the rapid loading and discharging of it. The vessel is fitted with a set of triple expansion engines, which are capable of giving her a speed of 11 knots. B. T.

Lake Steamer for Russia.

We present a photograph taken after the launch of the paddle steamer *St. Peter*, built by the Grangemouth and Greenock Dockyard Company, Limited, Clyde, for Russia. The leading dimensions are 190 feet by 26 feet by 9 feet. She has a long fore-

THE ST. PETER JUST AFTER BEING LAUNCHED.

castle, bridge and poop. The first-class cabins are in the forecastle; the second-class cabins in the poop; the officers' accommodation is on the wings; and third-class accommodation is provided on the lower decks forward and aft. The cargo holds are forward and aft of the machinery space, with hatch, winch and derrick to each. The vessel has a two-masted fore-and-aft schooner rig; and has steam steering gear, steam windlass and electric light throughout, including powerful search light. She was built to No. 3 British Board of Trade passenger certificate.

The compound surface condensing diagonal paddle engines have cylinders 23 and 48 inches in diameter by 51 inches stroke. There is one large single ended boiler, working at 130 pounds pressure. The speed is 15½ knots. The vessel is built on very fine lines and is of elegant appearance and design.

She is intended for service on Lake Ladoga, North Russia. B. T.

THE SOUTH AMERICAN RIVER STEAMER ASUNCION ON TRIAL TRIP.

The captain of a transatlantic steamship is authority for the story that, after a trifling mishap had been repaired, a lady passenger inquired of him what the matter had been. He replied that there was a little difficulty with one of the screws, but that it had been repaired, and that everything was then all right. The passenger expressed her gratification that the difficulty had been overcome, and at the same time complimented the captain upon his skill in righting matters, adding reflectively: "After all, why should we worry, even if there was something the matter with the screw? It's under the water and doesn't show."

American Machinist.

INTERNATIONAL MARINE ENGINEERING

Published Monthly at

17 Battery Place - - New York

By MARINE ENGINEERING, INCORPORATED

H. L. ALDRICH, President and Treasurer

8 Finsbury Square - - London, E. C.

E. J. P. BENN Director and Publisher

PROF. W. F. DURAND, Advisory Editor

SIDNEY GRAVES KOON, Editor

GEORGE SLATE

Vice-President and New York Representative

Branch Offices: Philadelphia, Pa., Machinery Dept., the Bourse, S. W. Anness.
Boston, Mass., 170 Summer St., S. I. Carpenter.
Chicago, 34 Clark Street, Howard S. Moss.
Midlands, 2 Sandhurst Road, Moseley, E. E. Starke.

TERMS OF SUBSCRIPTION

	Per Year	Per Copy
United States, Canada and Mexico	$2.00	20 cents
Great Britain and Ireland	10/6	1/
Other countries in the Postal Union	10/6	1/

Entered at New York Post Office as second-class matter.
Copyright, 1906, by Marine Engineering, Inc., New York.
International Marine Engineering is registered in the United States Patent Office.
Copyright in Great Britain: entered at Stationers' Hall, London.

Notice to Advertisers.

Changes to be made in copy, or in orders for advertisements, must be in our hands not later than the 5th of the month, to insure the carrying out of such instructions in the issue of the month following. If proof is to be submitted, copy must be in our hands not later than the 1st of the month.

The edition of this issue comprises 6,500 copies. We have no free list, accept no return copies and issue only enough to supply the regular demand.

International Marine Engineering.

Our change in name becomes this month a change in fact, with the complete establishment of an edition published in London simultaneously with the regular edition in New York. We have long had in mind a change of this sort, based partly upon the rapidly increasing extent and importance of our foreign connections, and partly upon the desire to enter the field more fully in Great Britain, the greatest shipbuilding and ship-owning region on the face of the earth. We feel that in so doing we have before us a future of great promise and of great usefulness. There is so much to be learned regarding methods of construction, which each of the two great English speaking nations can show the other, that, with descriptions which we publish month by month of the vessels constructed on both sides of the Atlantic, it cannot be but that great benefit must be derived by our readers from a careful study of the conditions prevailing, not only in their own shipbuilding yards, but in those on the other side of the water.

We are taking this step at a time when the shipyards of Great Britain are extremely busy, having on hand an immense tonnage under construction, and turning it out with a celerity and at a cost of production which challenge the admiration of the seafaring world. In striking contrast with this prosperous state of affairs, the yards of the United States, aside from certain exceptional instances, are at a very low ebb on the wave of prosperity, and many of them are with difficulty keeping afloat. This condition of course does not prevail upon the Great Lakes, where a special type of ship has been evolved to meet special conditions, particularly in the way of carrying bulk cargo; and it does not prevail to the highest extent in such of the yards on the Atlantic coast as are supplied with liberal orders from the federal government. But in general, and particularly in connection with the construction of tonnage designed for deep sea work, the American shipyards are in a very languishing state.

During the first quarter of the present calendar year, the yards of the United States turned out 202 vessels against 183 for the United Kingdom, but when we come to a question of tonnage the story is quite different; for the United States' tonnage was 106,834 and the British 368,451. This gives the American ships an average of only 529 tons as against 2,010 tons for the British; and as the value of a ship for commercial purposes increases considerably faster than does the size, it is quite apparent that the British tonnage is of immensely greater value on the average than is the American.

It has always been our policy, and this policy will continue, to do all we can in the direction of upbuilding the merchant marine in a scientific manner. For the United States it is evident that this upbuilding will be virtually in the nature of an entirely new construction, for the amount of American shipping now engaged in foreign commerce is almost at the lowest figure which it has reached during the past hundred years.

Marine Power Production.

There has rarely been a period in the history of the world in general, and of power production in particular, when so many different methods were in evidence for revolutionizing, or, at any event, seriously modifying, practice than at the present time, along the line indicated by the heading. The reciprocating engine, which has had an immensely useful career, extending over a full century, has been recently to some extent supplanted by a rotary engine of the steam turbine type, and indications are not lacking that for high speed work the turbine will be the prime mover par excellence of the immediate future.

It should not be forgotten that except for a special class of work the turbine is not at all well suited from an economical point of view. It is well known that

theoretically the turbine as now constructed will operate at its best efficiency when the linear velocity of the blades or vanes approximates to one-half that of the steam impinging upon them. To provide conditions such as these, it would be necessary for the turbine to rotate at an extremely high number of turns per minute, with the alternative of having turbine drums of excessive diameter. The latter contingency is one which is inadmissible on board ship, both by reason of the lack of space to be devoted to such a purpose, and by reason of the fact that such constructions would be extremely heavy, and could not be accommodated within the restricted schedule of weights allotted to the propulsive elements of the vessel. The problem of high rotative speed is one in which the efficiency of the propeller is directly implicated. It is well known that, in general, propellers are not efficient at extreme speeds of rotation, this being due to a certain extent to eddy disturbances in the water, and to the formation under extreme conditions of regions of vacuum along portions of the blade, giving rise to the phenomenon known as cavitation. We thus have, in driving a propeller by a steam turbine, the mutually antagonistic conditions of high turbine efficiency and low propeller efficiency with high speeds of rotation and of high propeller efficiency with low turbine efficiency at low speeds of rotation.

Where the turbine has been fitted, the results in each case have shown a compromise between the efficiencies of the two instruments, the propeller being operated at a higher speed than that at which the best efficiency could be obtained, and the turbine at a lower speed. To obviate the difficulties of this sort of arrangement, a scheme has been proposed which in its essence was suggested many years ago, and discarded as wholly out of the question on account of excessive weight. This proposition is no less than that of driving the propellers by electric motors receiving their current from generators operated by steam prime movers. In the older types of construction, with the slow running reciprocating engine, such a proposition as this would call, for a given power, for almost double the weight which would be required for direct drive by the steam engine, and the great advantage of extreme mobility and flexibility of operation would be necessarily neutralized by the losses inherent in both generator and motor, comparatively slight though these losses might be.

The new proposition, however, takes advantage of the relatively high efficiency of the steam turbine at high rates of revolution—an efficency higher than that possible with the reciprocating engine as we know it today—and by operating a generator at this high speed, both turbine and generator may be made of small size and light weight as compared with the power which they transmit. The motor attached to the propeller shaft may then be designed to operate at such speed as is best suited to the propeller, and without loss of electrical efficiency. We thus have the same conditions as prevailed before, except that probably more than half of the excess weight will be saved (it is even claimed that with properly designed plants there will be no excess weight) and we have an outfit operating at a much higher efficiency than was the case formerly; hence the slight losses incident to the operation of the electric units can be considered to be more than counterbalanced by the more economical operation from the steam end of the plant. We retain the flexibility of the system, which may be readily controlled from the pilot house direct, instead of through the intermediation of the engine room by means of telephonic or telegraphic orders. The project is as yet only in the infancy of its development, but it is reported that experiments are under way which bid fair to throw a flood of light upon the subject.

The internal combustion motor furnishes another source of power which is extremely convenient to use under certain circumstances. The heat efficiency of this form of apparatus is considerably greater than that of any steam plant yet devised, and the weights required for the installation of the plant are much less than with steam. For large powers, this system has not been developed to such an extent as to warrant its present adoption, but improvements are being continually made which seem to point to the inclusion of large powers in engines of this sort at no distant date. In this connection, the development of the producer gas plant is being watched with a great deal of interest, and unquestionably there is a great field ahead for this type of mechanism.

One great disadvantage of the gas engine has been that the fuel which it uses could be obtained in only a comparative limited quantity, and at a price which is even now showing the signs of a rapid rise. We have in another column an article concerning the use of alcohol in engines of this type, and describing the relatively minor changes in mechanism required for this purpose. Alcohol can be produced in almost unlimited quantities from a large variety of plants, one common source in Germany being the potato. There is thus little opportunity for any decided rise in price, and although at present the cost of a unit of power with alcohol is greater than that with gasoline, yet the conditions seem to indicate that before long there will be a parity between the two.

All of these different forms of prime movers are in process of rapid development and exploitation, and each unquestionably has a certain portion of the field which it can fill with a higher degree of satisfaction than can any of the others. An ultimate outcome of the competition as among these several factors cannot be predicted, and, indeed, it is not improbable that before practice crystallizes into one or another of these forms, something new will be developed as a competitor.

ABSTRACT FROM RULES AND REGULATIONS OF BUREAU VERITAS.

EDITION OF 1905.

ARRANGED BY HARRISON S. TAFT.

PART III.

16. Deck and Hold Beams.

1. Under all laid decks, including full poop, bridgehouses, forecastles, and raised decks, the beams are to be located on alternate frames, with half beams in way of all hatchways or other deck openings. The spacing of beams for a steel deck not covered with wood is not as a rule to exceed the frame spacing.

2. When a steel deck is worked with no wood covering the beams under said deck are to be located on every frame, with a girder, whose sectional area shall equal that of the required deck beams worked under said beams in way of the stanchions. Under windlasses and winches beams are to be worked on every frame.

3. In way of the fore hold it is advisable to consider the actual depth of said hold rather than the midship depth. In double bottom vessels the molded depth in way of same may be reduced by an amount equal to the difference between the tabulated depth of floors and that of the double bottom in determining the depth for arrangement of deck and hold beams and side stringers of tables 3, 4, and 5; but said reduction may not exceed 12 inches.

4. Half beams in way of hatches may be ⅛ less in weight than the tabular requirement.

5. Beams at ends of hatches over 6 frame spaces in length, and mast beams at wedging deck in sailing vessels, must be one inch deeper than otherwise.

6. When quarter stanchions are fitted but are not required by the rules, the deck beams may be of reduced scantling.

7. Deck and hold beams may be reduced at the ends of a vessel. Said reduction is not to exceed ⅛ of the required midship weight.

8. When plate knees are adopted the beams must extend to the shell of the ship and be riveted to the frame itself as well as to the knee.

9. For number of tier of deck beams, spaced two frame spaces apart, and strong hold beams spaced ten frames spaces apart, see table No. 3.

10. If a deck is worked in lieu of strong hold beams, the beams of said deck are to be spaced not over two frame spaces apart.

11. Strong hold beams are to be secured to the stringer plates by bracket plates, of the same thickness as the stringer plates. Said bracket plates being two frame spaces in length (fore and aft) and one frame space in breadth (athwarthship).

12. *a.* When the molded height between decks exceeds 8 feet additional compensation will be required in between deck spaces.

b. When said height is less than 7 feet 6 inches additional compensation will be required below the lowest tier of deck beams to that given in tables 3, 4 and 5.

13. If more than 40 percent of the total number of required beams are cut or if the total length of all hatchway openings exceeds 40 percent of the vessel's length, including all deck openings for cargo, machinery, etc., the remaining beams must be of increased scantling. Also the plating between hatches.

14. Beams to which web frames are attached must be of strong hold beam size.

15. As many through beams as possible are to be worked in the machinery space.

16. In Sailing Vessels.

a. When said vessels are of 19 feet molded depth to second deck, the third tier of deck beams may be dispensed with if a strong plate stringer with knee brackets is worked in hold in lieu of same.

b. Two side stringers consisting of an intercostal bulb plate riveted between two angle bars; or an intercostal plate riveted between two bulb angles may be used in place of said plate stringer. The angle bars must extend the entire length of the vessel with gussett plates at both ends. The bulb or intercostal plates are to be secured to the shell plating by angle clips for the ¾ vessel's length amidships.

17. Panting Beams.

Panting beams with suitable stringers are to be fitted in the forward end of sailing vessels and paddle steamers, but in both ends in screw steamers. The stringers are to be clipped to the shell, being spaced not more than 4½ feet apart. The panting arrangement should extend well abaft the collision bulkhead.

17. Beam Knees.

1. In general welded or plate beam knees are to be in depth not less than 2½ times the depth of the beams they are fitted to. The depth across the throat shall be at least 1¾ times the depth of said beams.

2. When a tier of beams is omitted the depth of the beam knees of the deck beams immediately above said suppressed deck is to be three times the tabular depth of the beams.

3. In single deck vessels of 22 feet or more in depth the depth of the beam knees is to be 3½ times that of the beam and four times if the molded depth exceeds 26 feet.

4. In sailing vessels all the beam knees are to be in depth at least three times the depth of the beam to which they are secured if the upper deck beams exceed 36 feet in length.

5. Knee brackets to web frames are to be on each side three times the depth of the web frame beam.

18. Deck Plating. Deck Stringers and Ties.

1. Deck Plating.

a. The midship thickness of the deck plating is to be maintained for ½ length amidships, with a gradual

reduction toward the ends to not less than ¼ inch thick even when covered with wood. Between hatchways the plating may be ⅛ less in thickness than otherwise, but to be not less than ¼ inch thick even if covered with wood.

b. Partial steel decks are to taper at their ends into the deck stringers and tie plates for a distance equal to 1-12 the vessel's length at each end.

c. Plated decks must not be cut at a bulkhead.

d. All plated decks must be caulked unless covered with a wooden deck caulked watertight.

e. When a required plated deck is suppressed in vessels with deep frames or web frames in lieu of a beam tier, extra compensation must be made for the suppressed deck.

f. The thickness of the upper deck plating in a vessel of the one, two or three deck type is to be increased by 50 percent between the stringer plates and the hatch coamings, and by 25 percent between the hatches whenever a required second deck is dispensed with in said vessels. Similar compensation is to be made for the suppression of a lower deck in cases where more than two decks are required.

g. When the length of a hatchway is over 9 frame spaces and a plated deck is required, the strake next to the hatchway is to be ⅛ inch thicker than otherwise for the full length of the hatch. If no steel deck is required, the space between the tie plates and stringers is to be plated over with an increase in width of the tie plates as stated below—3-*c*. Said plating to extend for the full length of the opening and thence taper for at least six frame spaces into the stringer plates.

h. The corners of all deck openings which exceed six frame spaces in length must have doubling plates or otherwise at same.

2. Deck Stringers.

a. A plate stringer is to be worked at the ends of all tiers of deck and hold beams. They are to maintain their midship scantling for the ½ length amidships. The width of the stringer is to be measured from the inside edge of the framing when the stringer plate is cut out for the frames, otherwise from the shell plating.

b. Upper deck stringers plates, water angle bars and angle bars around the coaming plates, are to be calked watertight whether or not covered with wood or cement.

c. The stringer plates may be ⅓ less in width when a steel deck is worked from what their width would be for a wooden deck. Said reduction is to extend for the ½ length amidships. If the deck is only partly plated over said reduction of ⅓ is to cover only that part of the deck which is plated.

d. In vessels of 400 feet or more in length an intercostal gunwale bar is to be fitted between the frames on the under side of the upper deck stringer in addition to the regular gunwale bar on the upper side of said stringer plate. Said intercostal clips are to be of the same scantling as the regular gunwale bar.

e. In two and three deck vessels (outside of the awning deck class) the depth regulating the width of the stringer plates must be taken to the second deck when said deck is to be plated instead of the upper deck.

3. Tie Plates.

a. All vessels are to have fore and aft tie plates on each side of the hatchways on every tier of regular deck beams when no steel deck is fitted. They are to be worked continuously and be riveted to the stringer plates at their ends. They are to maintain their midship dimensions for the ½ length amidships, with a reduction in thickness fore and aft of said ½ length.

b. Angle bars of the same cross sectional area may be substituted in place of the tie plates if desired on non plated decks.

c. In way of hatchways and other deck openings of more than 6 frame spaces in length, the tie plates are to be twice their ordinary width with a gradual reduction beyond said hatchways to their required width.

d. Longitudinal tie plates are to be fitted to all poops, forecastles, bridgehouses, awning decks and the deck below, where not plated.

e. Diagonal tie plates running from the mast partners to the side stringers must be fitted on all upper and second decks, when no metal deck is laid, being of the same size as the fore and aft tie plates. Said diagonals will not be required at the mizzen mast on the upper deck of steamers when no poop is fitted. Said diagonal ties must be well riveted to the fore and aft ties, to the mast partners, and to the stringer plates.

f. Said diagonal tie plates are to be fitted on poops, forecastles and bridgehouses whose length exceeds ¼ that of the vessels, when not plated.

g. Plates of not less thickness than the mast partners are to be fitted under all cranes and winches.

h. Wherever the deck planking is cut by a coaming or a bulkhead a tie plate at least 6 inches in width must be fitted to take the ends of said planks.

4. Mast Partners.

a. Mast partners are to be fitted at all masts on non-plated decks. They are to equal in thickness the deck tie plates, being in breadth at least twice the diameter of the mast hole (three times said diameter at the wedging decks of sailing vessels) and are to extend for four frame spaces in a fore and aft direction.

b. When the wedging decks are plated doubling plates are to be fitted at the masts, being of the same thickness as the deck plating itself.

c. A coaming ring of keelson angle size is to be fitted at the wedging deck for wedging.

5. For deck plating, deck stringers and ties in different types of vessels, see sections 32, 33, 34, 35 and 36.

19. Stanchions.

1. If possible stanchions are to be fitted under each tier of beams, being spaced in general not more than two frame spaces apart.

2. In screw steamers for ⅛ the vessel's length forward, and at each end in sailing vessels, the stanchions can be spaced not more than 4 frame spaces apart. When a steamer's longitudinal number exceeds 360,000—180,000 in case of a sailing vessel—the stanchions are to maintain their midship spacing all fore and aft in said vessels.

3. In large single deck vessels of tables 4 and 5 it is recommended to have two rows of stanchions, fitted under each strong beam, with a strong fore and aft girder fitted to the heads of the stanchions in each row, so as to support the intermediate beams.

4. When a vessel is of 44 to 56 foot beam a row of quarter stanchions must be fitted, (the center row of stanchions being omitted), spaced not over two frame spaces apart. But if the center row of stanchions is fitted, said center stanchions are to be fitted not over two frame spaces apart and the quarter stanchions not more than four frame spaces apart.

5. When a vessel's beam is 56 feet or over, the center and quarter stanchions must be fitted to each beam tier, wherever the length of a beam exceeds 44 feet; said stanchions being spaced not more than two frame spaces apart.

6. In poops, bridges and forecastles a stanchion is to be fitted at every alternate frame. In vessels whose longitudinal number exceeds 350,000, it is advisable to put two stanchions at every alternate frame in the forecastle.

7. Stanchions are to be fitted at the corners of all hatchways. When the fore and aft length of a hatchway exceeds 6 frame spaces there is to be at least one stanchion fitted under each of the fore and aft carlings of said hatch. Two such stanchions are to be fitted when the length exceeds 9 frame spaces.

8. A stanchion should be fitted under the corners of large deck houses. Additional stanchions should be fitted under all winches, cranes, windlasses, steering gears, and other heavy deck fittings.

9. The diameter of a solid stanchion is to be determined by the transverse number and length of said stanchion. The external diameter of a hollow stanchion is to be 1.4 times that of the solid stanchion in lieu of which it is used, its internal diameter being 1.15 times that of said solid stanchion.

10. When the diameter of a round stanchion exceeds 5½ inches it is recommended to adopt built up stanchions of suitable shapes.

11. All round stanchions are to have solid forged heads and heels. Whenever possible the heels of the lowest line of stanchions should be secured to a keelson.

12. Bulwark Stanchions. Said stanchions are to be spaced not more than 6 feet apart and are to be from 1¼ to 2 inches in diameter.

20. Bulkheads.

1. A watertight bulkhead extending from the bottom to the upper deck in all cases is to be located aft of the stem, at a distance equal to 4 percent of the vessel's length plus 7 feet, said bulkhead being bracketed to the shell. It is recommended that another bulkhead of similar construction be located a short distance abaft the above forward collision bulkhead.

2. A watertight bulkhead with extra heavy stiffeners should be fitted at each end of the machinery space. Also at the inner end of the stern tube, at a suitable distance from the stern post, being secured to a steel deck or flat so as to enclose said tube in a watertight compartment.

3. Bulkheads should be so located as to divide the ship into a sufficient number of compartments that said vessel will float if any one or two of said compartments be open to the sea. In steam vessels no compartment should exceed 90 feet in length.

4. A fore and aft bulkhead should be fitted on the center line in all athwarthship coal bunkers in steamers of 36 or more feet in breadth to prevent the shifting of the coal.

5. Sailing vessels of 250 feet or more in length should have at least one watertight bulkhead amidships. Two such bulkheads should be fitted if the length is 300 feet or over.

6. All bulkheads must extend to the upper deck except in awning deck vessels, where they are to extend to the second deck.

7. No doors will be allowed in the collision bulkheads. Doors in other watertight bulkheads must be as few as possible. They are to be made absolutely watertight and shall work from a deck located above the load water line. When a bulkhead is stepped at a deck no opening will be allowed in the watertight flat between the two parts of it.

8. The two end peaks are to have their bulkheads tested for watertightness by filling said peaks full of water. All other watertight bulkheads and their doors are to be tested by fire-hose.

9. Watertight bulkheads are to have double or single frame angles as stated under section 6, paragraph 7.

10. All bulkhead stiffeners are to be of the same size as the main frames, worked vertically on one side—horizontally on the other. The vertical ones are to be spaced not over 30 inches apart extending the whole depth of the bulkhead; the horizontal ones not more than 4 feet apart, extending from floors to upper deck on the forward collision bulkhead, but to the second deck on all other bulkheads. When a bulkhead is 40 feet or more in width the horizontal stiffeners are to be of bulb angle of deck beam size of same length. All vertical stiffeners are to be secured to the tank top and deck plating by plate brackets.

11. A center vertical web plate stiffener of suitable size is to be fitted in addition to the above stiffeners to all bulkheads of 36 to 45 feet in width. Two such webs are to be fitted if the width is of 45 to 55 feet; three webs if the width is 55 feet and above.

12. The bulkhead plating is to be secured to the tank top by double angle bars single riveted, or by a single bar double zigzag riveted in both flanges.

13. An efficient girder is to be fitted in way of the strong hold beams when said beams are worked in lieu of a deck.

14. The thickness of the bulkheads at each end of ble angle bars.

The plates are to be secured to the deck plating by doua raised deck is to equal the raised deck side plating.

15. The transverse bulkheads at the ends of a poop, forecastle or bridgehouse are to equal the side plating of said structures, having vertical stiffeners not over 30 inches apart; said stiffeners being bracketed at top and bottom.

21. Shaft Tunnel.

1. The plating of said tunnel is not to be less in thickness than required for the lower part of watertight bulkheads. Under hatchways the thickness of the plates must be increased by ½, or else doubling plates or a wood sheathing fitted.

2. The angle bar stiffeners are to be spaced from 4 to 5 feet apart.

3. The tunnel must be locally strengthened wherever a mast or stanchion is steeped on same.

4. There shall be a well in the aftermost part of the tunnel.

5. There shall be a watertight door at the forward end of same to work from above the load water line.

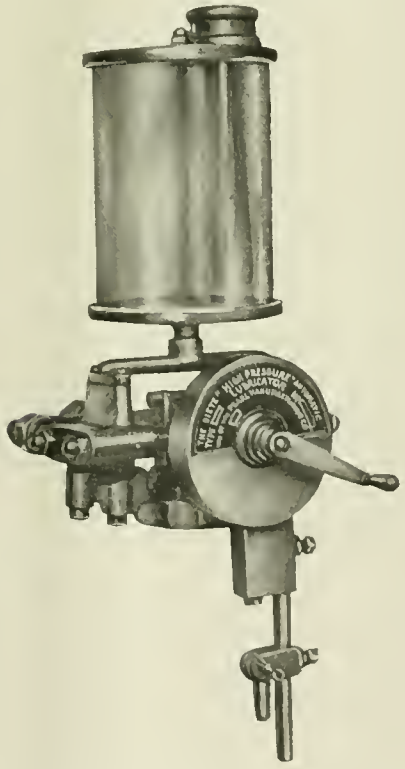
6. A stuffing box shall be fitted to the shaft where it passes through the bulkhead at the after part of the engine room.

7. All tunnels shall be tested by hose for watertightness.

ENGINEERING SPECIALTIES.

The Dietz High Pressure Automatic Lubricator.

In the accompanying cut is shown the latest type of automatic force feed lubricators, brought out by the Pearl Manufacturing Company, 344 Oak street, Buffalo, N. Y. Several new features, not heretofore used in apparatus of this kind, are incorporated in its construction. The design of the valve gear of the oil pumps composing the lubricator is especially interesting, as the valves are mechanically operated from the main spindle by means



of cams, which insures their opening and closing at the proper time, no matter what the consistency of the oil may be. The valves proper are of the poppet type, and are made of steel. This construction adapts the pump specially for the handling of oil and graphite mixtures, as with this valve gear there is no chance of sticking or clogging of the valves.

Another good feature of this lubricator is the accessibility of the valves, which by removing the caps, may be withdrawn from the cylinder for inspection or cleaning, without disturbing any other parts. The driving mechanism is positive by means of a ratchet, inclosed in a dust-proof casing, the same casing forming a bearing for the rocker arm.

The pump is driven in the usual way by connection to the valve rod of the engine, and the feed is varied by changing the travel of the rocker arm. There is a crank by means of which the pump may be worked by hand in starting, or in case an extra amount of oil be required at any time. The eccentric and the cams are cast in one piece, which insures their correct relative position at all times. They are carefully ground and hardened.

The valve rods, which are supported by the long stuffing box gland and reach back into the valve stems, are made of tool steel, and are carefully tempered at the ends. A sight feed glass is placed near the steam line, and shows the amount of oil being delivered after it has passed the pump and has entered the steam space of the engine. The lubricators are furnished either single or double acting, with from one to six feeds, and with reservoir capacities of from one pint to one gallon.

Linotile and Rubber Tiling.

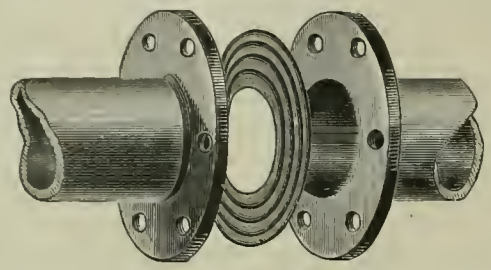
The illustration shows an anchor form of tiling which is made in a number of colors by the Anchor Tile Company, of Trenton, N. J., and with which a pleasing variety of patterns for floors can be obtained. This tiling forms a continuous and tenacious sheet about ¼ inch thick, and is especially adapted for use wherever it is liable to be subjected to vibration or shock. It is practically noiseless and is not slippery, wears well, is waterproof and readily cleaned. No special preparation is required for

laying it on the floor, and its qualities make it very suitable for steamships, yachts and many other purposes for which this sort of floor is needed.

Linotile has about half the weight of the rubber tiling, and can be laid at about half the cost. One advantage which it has over the rubber is that it is not affected with regard to expansion and contraction by changes of temperature. It is said to be very durable. In both of these types of tiling, which are made of the same pattern, worn places can readily be removed and replaced, whereas sheeted floorings would cause considerable difficulty in this respect.

A Corrugated Copper Gasket.

This metallic gasket may be used in place of rubber or other destructible materials in general use for packing. It consists of thin sheet copper, stamped with concentric corrugations. Three to six corrugations are all that are necessary, so that the space within the bolt holes determines the width of the gasket. In cases where the flanges are thin, and for this reason are liable to bend when the bolts are tightened, it is advisable to



extend the copper gasket to the full width of the flange. This will of course require the cutting of bolt holes in the gasket. Connections made with these gaskets are said not to blow out after continued use, for each corrugation makes the entire circle of the flange, and so long as the contact is kept complete by compression, the joint cannot leak. This gasket may be put in place while steam is leaking through valve, and is said to answer well on pipes in which steam is alternately on and off, for it is not impaired by the repeated expansion and contraction. The makers are the Taunton-New Bedford Copper Company, of Taunton, Mass.

The Hauck Burner.

A very powerful flame for heating metals to be treated in various ways in the way of repair, etc., has been placed upon the market by the Oil-Fuel Engine Company, 225 South street, New York City. The fuel used is any crude or fuel oil.

This device has been tested with excellent results, and has been applied for work in boiler shops, in which it is used for flange turning, bending plates, laying on patches and bending pipes, while it is used for purposes of welding and forging in black-

smith shops, and for annealing, brazing and bending in coppersmith shops. It has also been used for bridge and structural iron work, for annealing frame plates, for bending, straightening and wedding use on board ships; for heating cranks when necessary to remove the crank pins, as well as for a great variety of other uses under the head of repair work. The pressure used in the tank may vary from 15 to as much as 100 pounds per square inch, the flow of oil to the burner being regulated by means of valves. The weight of the outfit is about 100 pounds.

Some of the operations which have been accomplished in a short space of time include the bending of a 1-inch steel plate 6 by 8 feet at right angles in fifteen minutes, the amount heated being 8 inches by 8 feet; annealing an 8-inch pipe 16 feet long in six minutes; brazing a cup joint on this pipe in five minutes. The heating of a crank pin 14 inches in diameter and its removal from the crank arm required one hour and fifteen minutes.

A New Pipe Threading Machine.

The machine which we illustrate uses a direct-connected pulley by means of which power is transmitted. In the machine a worm gear is used for feeding, as it is found more powerful than bevel gears. As a means of reducing friction, the worm gear is equipped with ball bearing thrust collars. The dies, which consist of four pieces, are made of high grade steel, and can

readily be reground without changing the shape of the cutting face. They are adjusted by means of a face plate, and the die head is so designed that when the dies are in place and the pressure of the pipe against them they become self-locking and cannot slip. The pipe is clamped in the vice by a wheel of sufficient size to insure its being held perfectly rigid.

The machine is placed on the market by the Loew Manufacturing Company, of Cleveland, Ohio, and is made in three sizes, taking in pipe from ½ to 6 inches in size.

TECHNICAL PUBLICATIONS.

Modern Engineering Practice: A Reference Library. Edited by Frank W. Gunsaulus, President Armour Institute of Technology. Size 6½ by 9½ inches. In twelve volumes covering 6,000 pages and 4,000 illustrations. Chicago, 1906. American School of Correspondence.

Written for the purpose of instruction in various phases of engineering practice, these volumes cover a wide range of subject, and take up each item in a very simple manner, such as is suited to the needs of a student without technical training. They have been compiled by a large list of writers and collaborators, and authorities on the various subjects have been freely consulted in their preparation. In addition to this many engineering firms have given great assistance in the way of photographs and information regarding the latest practice along the several lines. The general scope of the work can be best illustrated by a list showing the contents of the several volumes. The list is as follows:

I. Electricity, general principles; wiring; telegraphy; welding, etc.

II. Dynamo electric machinery; motors; storage batteries and automobiles.

III. Management of electrical machinery; power stations; electric lighting; electric railways.

IV. Alternating current machinery and power transmission.

V. Telegraph engineering and operation.

VI. Principles of heat; chemistry; boilers, pumps and valves.

VII. The steam engine; valve gears; thermo-dynamics; steam turbines; refrigeration; internal combustion engines.

VIII. Marine boilers; marine engines and condensers; navigation; locomotive boilers and engines; valve motions; air brakes.

IX. Pattern making; machine design; foundry work; shop management.

X. Machine shop work of all sorts and varieties.

XI. Mechanical and perspective drawing and lettering.

XII. Ventilation; heating; plumbing; sewerage; carpentry.

The first half of volume VIII covers with considerable detail the general subject of marine engineering so far as it relates to the more usual types of boilers and engines. Numerical examples are used showing the application of various principles, and copious use is made of illustrations of all sorts, particularly sketches showing the relations of the several parts each to the other. In addition, a number of photographs are given of notable constructions in the line of marine machinery and of complete ships.

The Directory of Shipowners, Shipbuilders and Marine Engineers. Size 8½ by 6 inches. Pages 637. 1906. The Directory Publishing Co., 3 Ludgate Circus Buildings, London, England. Price 10s.

As its title implies this volume details all that appertains to shipbuilding, and is in fact a complete guide to "who's who" in the shipbuilding world. The compilers are to be congratulated upon their work, as great care has been apparently taken to issue a reliable book, which is invaluable for reference purposes.

The volume contains the names and addresses of all the chief officials in the shipowning, shipbuilding and marine engineering firms, and also gives such particulars as services, lists of boats, with tonnage, etc. The index, which is very comprehensive, is a special feature of the book, and enables immediate reference to companies, officials and boats.

Steam Turbines: Their Theory, Calculation and Construction. By Gabriel Zahikjanz. Size 6¼ by 9½ inches. Pages 179. Figures 23. Berlin, 1906. M. Krayn, 11 Kurfuerstenstrasse. Price in paper covers 6 marks; bound 7 marks, 50 pf.

This work goes with characteristic German thoroughness into the general theory of the turbine, taking up particularly the subject of the theory of flow of a liquid under pressure in constricted passages. The general subjects handled are: pressure; power; methods of building; graded speed steps; expansion of steam; flow of steam; graded expansion; heat, and the fundamental law of the change of condition of steam; the energy of heat, of steam, and flow of steam; formulæ and numerical examples of steam turbine calculations.

The Indicator Hand Book. By Charles N. Pickworth. Part 1, The Indicator: Its Construction and Application. Size 4¾ by 7¼ inches. Pages 130. Figures 81. Manchester (England). Emmott & Company, Ltd., and New York, D. Van Nostrand Company. Price $1.50.

This is the third edition of the work, and includes, in addition to information in the previous editions, descriptions of various forms of continuous indicators, including the Cipollina indicator. The work has in general been brought up to date. It includes, of course, discussions of indicator cards; the use and care of the indicator; reducing gear; errors due to faulty connections; various methods of attachment of the indicator; besides descriptions of a large number of different types, showing construction of the various parts.

Shaft Governors. By W. Trinks, M. E., and C. Housum; size 3¾ by 6 inches; pages 97; figures 27; tables 16; New York; 1906. D. Van Nostrand Company; Price 50 cents.

This little work deals first with the theory of the shaft governor, basing it, of course, upon the centrifugal moments caused by the inertia of the various parts, and is to a large extent deduced from notes and formulæ evolved by the authors in their practice. The present volume covers simply the statics of shaft governing, and will be followed by a second volume covering gravity balance, speed variations and oscillations under change of load, etc.

The subject is taken up in considerable detail and well illustrated by diagrams, a number of the drawings being on folders in order to be accommodated within the limited size of the volume. The theory has been worked out by the aid of the calculus, and the book, as a whole, ought to be valuable to engineers dealing with this phase of their subject.

QUERIES AND ANSWERS.

All reasonable questions concerning marine engineering received from and signed by subscribers will be answered by the Editor in this column. All communications must bear the name and address of the writer.

Q. 348.—Please give the formula for figuring *actual* horsepower transmitted by marine gasoline engines, using this example: four cylinder engine, each cylinder having 8¼ inches diameter by 11 inches stroke, 300 revolutions. I cannot reconcile the horsepower figured on above engine on the yacht *Emil Capitaine* in your April number with the formula given by "A builder of Marine Engines" in one of your former numbers.

What is meant by "brake" horsepower? INGANNUS

A.—Brake horsepower is horsepower measured by means of a brake or other transmitting device, and would be in the case of a marine engine the horsepower actually transmitted to the shaft. It is less than the indicated horsepower, because the latter includes the power required to overcome the friction in the engine itself.

The example quoted would be figured out on the ordinary formula $\frac{p\,l\,a\,n}{33{,}000}$ where p for gas engines might be taken at 80 pounds per square inch; l is 11/12; a is the area of a circle, the diameter of which is 8¼ inches, this area being 53.45 square inches; and n is the number of working strokes per minute. As the revolutions are 300 per minute, the strokes will number 600 per minute; and as the engine is of the four-cycle type, there will be 150 working strokes for each cylinder or 600 in all. This formula gives the result as 81 indicated horsepower, so that the result given, 75 horsepower, is probably correct as regards power transmitted to the shaft.

The formula given on page 70 of our issue for February, 1906, is $\frac{d^2\,l\,n}{15{,}000}$, all dimensions being in inches. This figures out at 60 horsepower, which is somewhat less than that given above, being a very conservative estimate of results which might be expected under any and all conditions.

Q. 340.—Will you kindly explain fully the American Power Boat Association's measurement formula, which is as follows:

$$\text{Rating} = 16 \times \sqrt{\frac{\text{L. W. L.} \times \text{H. P.}}{\text{M. S.}}}$$

1. Why was 15 changed to 16, and what is the factor?
2. Why were stroke and revolutions omitted from horsepower calculation?

E. N. B.

A.—The formula is a speed formula, and it will give the speed of any vessel with great accuracy, where there is no distinct straight middle body, such as is found only in barges and heavy freight carriers. The factors are:

L. W. L. = length on load waterline in feet,
M. S. = midship section in square feet,
H. P. = indicated horsepower,
15 = constant.

The square root of the load waterline is taken, because similar models differ in speed as the square roots of their lengths.

Therefore this is a speed factor and is placed in the numerator. The horsepower is also a speed factor, and for this reason also goes in the numerator.

The midship section is a resistance factor, as its area measures the displacement, wetted surface, and angle of entrance and run. The form of the midship section has little bearing on the final result, as investigation has shown that with a given displacement a midship section with small wetted surface has larger angles of entrance and run, and vice versa; hence the resistance is substantially the same in all cases. A large midship section shows greater displacement, greater wetted surface, and greater angles of entrance and run than a smaller one, therefore has a greater resistance and requires more power to drive it at the same speed as a smaller one; or with the same power cannot be driven at the same speed. Being a resistance factor, it is placed in the denominator.

The cube root is taken, because the speed of a model varies practically as the cube root of its driving power.

The constant 15 was inserted in the formula to make the rating approximately the same as the load waterline of the boat. However, since the formula was written, so much greater power has been put into boats that this similarity of sizes no longer exists, except in cruising boats of moderate power.

The table of time allowances was based on these factors, and was made to favor the smaller boats slightly, as it was thought that in heavy weather the larger boats, by reason of their size, would more than make up for this. Experience, however, has shown that very few races are sailed in heavy weather, and most races have gone to smaller boats. For this reason the constant has been changed to 16, which reduced the time allowance somewhat, and so gives the larger boats a better chance to win.

In measuring the horsepower of gasoline engines, the stroke and number of revolutions taken as factors will give the fairest measure; but in practice it was found that while many owners were fair, still there were some owners and engineers who would resort to unfair methods calculated to deceive the measurer, by showing a much smaller number of revolutions than the engines would make in a race. To put an end to this kind of trickery and deception, the stroke and number of revolutions were omitted, and the piston speed arbitrarily fixed at 1,000 feet per minute in the high speed engines in automobile boats, and at 667 feet per minute in all others. This, with a mean effective pressure of 60 pounds per square inch of piston, gives the present formula of the American Power Boat Association. Practical considerations point to these speeds as being about the limits of efficiency, and any considerable increase of piston speed would probably show a lower net efficiency in the propulsion of a boat.

H. J. G.

Mammoth Stern Frames.

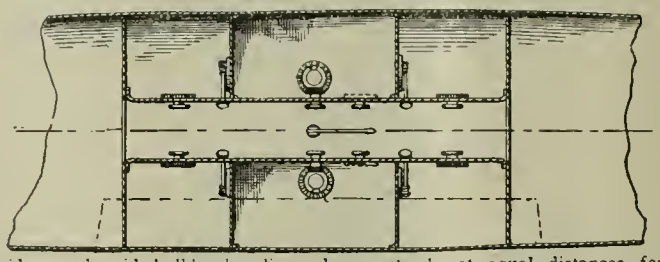
For the casting of the main piece of the stern frame for one of the new turbine steamers of the Cunard Line, now being constructed on the Tyne and Clyde rivers, 69 tons of molten metal were required, and as now finished its weight is 50 tons. The after brackets, which were cast singly, have a weight of 22½ tons each, while the weight of the forward brackets is 24 tons each These vessels will carry rudders weighing 70 tons, which, together with the stern frame and brackets referred to, make a total weight, for these parts alone, of approximately 220 tons. The enormous size of the main piece of the stern post afforded a problem in transportation of an unusual character, the dimensions of the frame far exceeding the load gauge of the British railways. This casting was shipped from the works of the Darlington Forge Company to Middlesbrough during a lull in traffic on a Sunday. The distance was covered in about six hours, the maximum speed of this "stern frame special" being 3 miles per hour. During the transportation of the casting it was found necessary to suspend all traffic on adjoining lines. Two powerful steam traveling cranes accompanied the train, these being brought into use upon arrival at Middlesbrough, from which point the casting was conveyed by water to the shipyards. *Iron Age.*

SELECTED MARINE PATENTS.

The publication in this column of a patent specification does not necessarily imply editorial commendation.

815,350. SUBMARINE BOAT. JOHN P. HOLLAND, NEWARK, NEW JERSEY.

Claim.—2. A submarine boat, having all of its water-ballast fuel-tank space included between two parallel tranverse, vertical bulkheads in the boat and extending to the hull thereof above, below and at both



sides, and said bulkheads, disposed respectively at equal distances forward and after the boat's center of buoyancy, and having fore-and-aft bulkheads between the transverse bulkheads and extending from top to bottom of the hull, said fore-and-aft bulkheads forming the sides of a fore-and-aft gangway through the tank-space. Five claims.

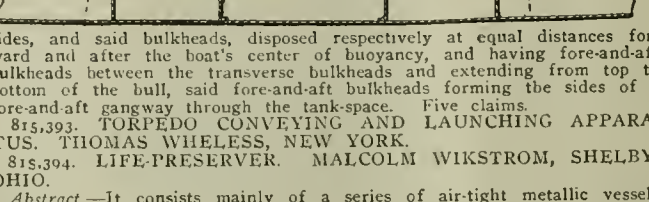
815,393. TORPEDO CONVEYING AND LAUNCHING APPARATUS. THOMAS WHELESS, NEW YORK.

815,394. LIFE-PRESERVER. MALCOLM WIKSTROM, SHELBY, OHIO.

Abstract.—It consists mainly of a series of air-tight metallic vessels which are spring-connected, so as to be yieldingly drawn together by the springs, which are preferably secured to the vessels, in tubular chambers or passages located between or within the side walls of the vessels, so that normally when the device is not distended the springs are entirely housed within the vessels and the device practically takes up no more space than that required for the actual bulk of the vessels. Five claims.

815,551. BARGE AND OTHER LIKE VESSEL. JOHN M. PEARSON, BELLEVUE, ASSIGNOR TO PEARSON MANUFACTURING COMPANY, ALLEGHENY, PENNSYLVANIA.

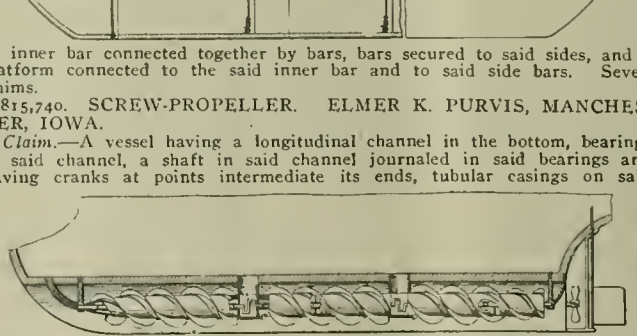
Claim.—3. A barge having a hollow metallic head-log at each end and between the sides thereof, said head-log being formed of an outer plate and



an inner bar connected together by bars, bars secured to said sides, and a platform connected to the said inner bar and to said side bars. Seven claims.

815,740. SCREW-PROPELLER. ELMER K. PURVIS, MANCHESTER, IOWA.

Claim.—A vessel having a longitudinal channel in the bottom, bearings in said channel, a shaft in said channel journaled in said bearings and having cranks at points intermediate its ends, tubular casings on said



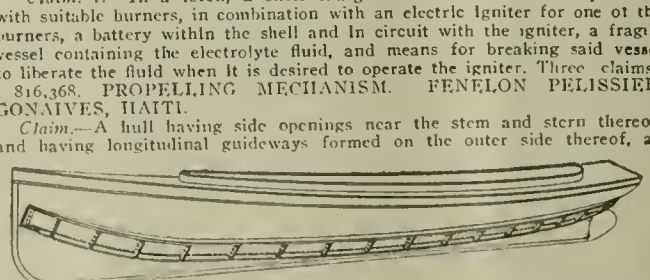
shaft, separated and spaced at the cranks and having their ends on opposite sides of the cranks closed, spiral propeller-blades on said casings, wells extending through and projecting from the bottom of the vessel, and casings at bottoms of the wells, communicating therewith, receiving the opposing ends of the tubular shaft-casings and incasing the cranks. One claim.

816,160. MARINE TORCH. JOHN D. GRAHAM, BROOKLYN, NEW YORK, ASSIGNOR TO MARINE TORCH COMPANY, BALTIMORE, MARYLAND.

Claim. 1.—In a torch, a shell charged with illuminant and provided with suitable burners, in combination with an electric igniter for one of the burners, a battery within the shell and in circuit with the igniter, a fragile vessel containing the electrolyte fluid, and means for breaking said vessel to liberate the fluid when it is desired to operate the igniter. Three claims.

816,368. PROPELLING MECHANISM. FENELON PELISSIER, GONAIVES, HAITI.

Claim.—A hull having side openings near the stem and stern thereof, and having longitudinal guideways formed on the outer side thereof, an



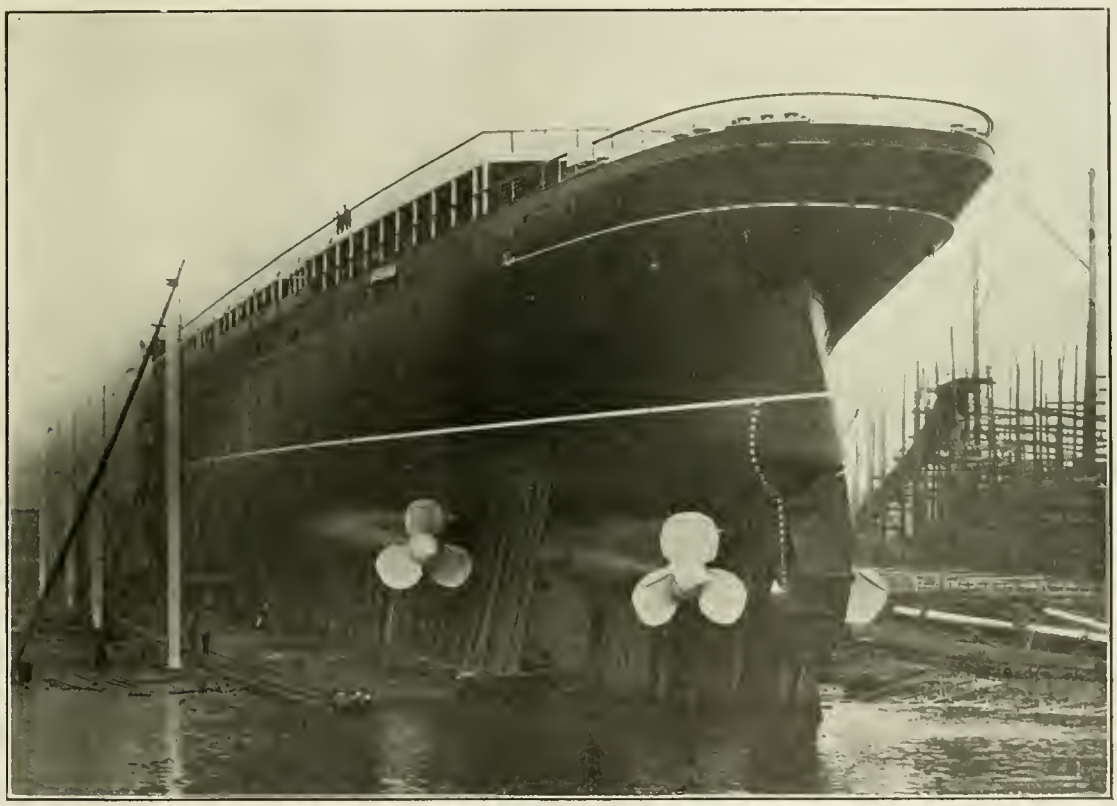
endless chain, paddles having bodies disposed at right angles to said chain and having oppositely-projecting arms disposed longitudinally with said chain, said arms being attached to said chain, and means for continuously driving said chain. One claim.

International Marine Engineering

AUGUST, 1906.

THE NEW CUNARD STEAMER LUSITANIA.

Sixty-six years ago the first Cunard steamer crossed the Atlantic. The *Britannia* was a marvel in her time, and boasted the proud strength of 740 horses, which carried her bulk of 1,154 gross tonnage at a speed of 8 knots across the Atlantic. After two-thirds of a century we witness the production of her monster successor, the *Lusitania,* with engines which will drive her 32,500 tons of bulk across the Atlantic at a speed of 25 knots. Just as the *Britannia* was built and engined on the Clyde so is the *Lusitania.* This latest addition to the Cunard fleet and to the Atlantic race of greyhounds has been built by John Brown and Company, Limited, Clydebank, in the yard formerly occupied by J. and G. Thomson and Company.



STERN VIEW OF LUSITANIA, BEFORE LAUNCHING, SHOWING THREE OF THE FOUR TURBINE-DRIVEN PROPELLERS.

The floating of the *Lusitania* on June 7, 1906, marks an epoch in the development of the steamship. She is to steam two knots faster than any previous steamer in the Atlantic service. All shipping men and engineers know the cost of addition to speeds over twenty knots. This addition of two knots has involved an addition of 70 percent to the 40,000 indicated horsepower developed by the present record holders. In the first ten years of steam navigation the speed reached ten knots; in twenty-five years it became thirteen knots. The first Cunarder, in 1840, steamed not over 8½ knots. In 1850 the Cunard addition reached 12.5 knots, doubling the gross tonnage and increasing the power three-fold. In 1892, with the last of the side-wheel Atlantic steamers, the speed was 14.4 knots. The *Gallia* in 1879 was the first of a new series of important ships, in which steam pressures were steadily increased, and the principle of steam expansion in the engine developed, with a relative reduction in weight of machinery. In the fifteen years from 1880 to 1895, a succession of record-breakers contested in speed, which was increased to twenty-two knots, with almost a tripling of the power and an increase of 80 percent to the gross tonnage. The Germans have since raised the speed to twenty-three knots, and the Cunard Company are now raising it to twenty-five knots.

The *Britannia* required only 570 tons of coal to propel her across the Atlantic, while the *Lusitania* will require about 5,000 tons. The *Britannia* burned 5.1 pounds of coal per hour per indicated horsepower for a speed of 8 knots, while the *Lusitania* will burn only 1.45 pounds for a speed of 25 knots.

The *Lusitania* is at present the largest, most powerful and fastest merchant ship afloat. She is unique in having quadruple screws, and has the turbine system in more comprehensive form than any other ship. The outermost screws are about 40 feet forward of the inner pair.

The following are the dimensions of the ship:

Length ..... 785 feet

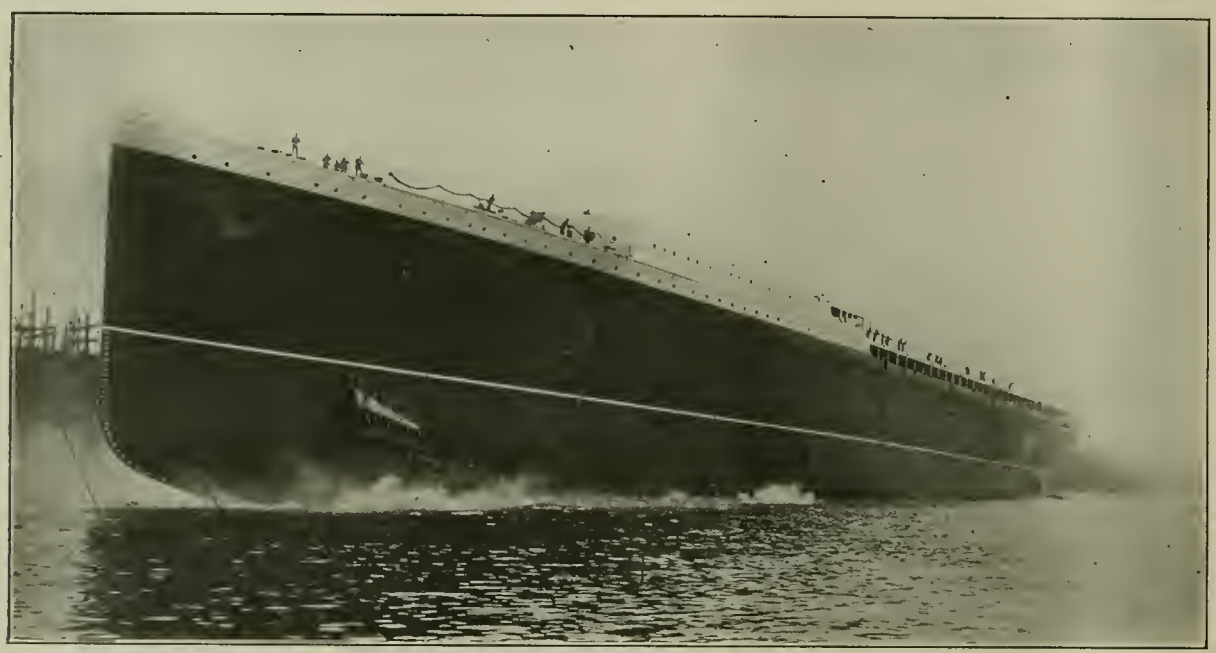
Breadth molded	88 feet
Depth molded	60 feet 6 inches
Gross tonnage	32,500 tons
Load draught	33 feet
Launching weight	16,000 tons

She is 160 feet longer than the *Campania*, and 78 feet 6 inches longer than the *Kaiser Wilhelm II.* The *Great Eastern* was 80 feet shorter, had 5 feet less beam, and 3 feet less depth than the *Lusitania*, which is relatively broader in the beam than her predecessors.

In determining the dimensions and general lines of the ship, John Brown and Company constructed an experimental tank, which is one of the largest tanks yet made. The carriage for the towing of the models and for the recording apparatus is electrically propelled. The carriage tows the model at a speed proportionate to the prospective speed of the proposed ship through a waterway 445 feet long, with a depth varying from 9 to 10 feet, and with a width of 20 feet. The models were 15.8 feet in length, and the speed at which they were towed was 365 feet per minute, equal to about 3⅔ knots. These models were tested over a range of speeds higher and lower than that proportionate to the trial speed of the actual ship, and they were run in three or four conditions of displacement. The apparatus automatically records the resistance in pounds, the distance traversed in multiples of 25 feet, the time in half-seconds, the measure of the current in the water as recorded by the revolutions of two log-screws running in advance of the carriage, and a graphic measure of speed from an instrument used for detecting any want of uniformity of motion. After the trials with the various models, the one which gave the speed required with the minimum resistance, and, therefore, with the minimum of engine-propelling power, was adopted. Further trials were conducted in connection with the four screw propellers which were deemed advisable, owing to the high power to be developed.

The hull is built on the double-bottomed cellular system, the depth between the bottoms being 5 feet. The keel plate consists of three thicknesses of plating, making a total thickness of 3¼ inches, and is 5 feet wide. The double bottom is a complete system of transverse and longitudinal girders riveted entirely by hydraulic power, and extends beyond the turn of the bilge. The framing extends thence to the top of the molded structure (about 55 feet). The plating is chiefly in 40-foot lengths, weighing from 4 to 5 tons. In some cases it has five rows of rivets. Four million rivets are in the structure, and these weigh collectively about 500 tons. The hull is divided by water-tight bulkheads, the doors in which can be closed or opened separately or collectively, by hydraulic power from a central station, or at the door itself, and all operations are under absolute control of the navigating officer. The stem is of forged ingot steel, connected by a steel casting to the center keelson, and the shell plates are rabbeted into it in the usual way. The stern frame and bracket for supporting the propeller shaft are of cast steel. The main pieces weigh nearly 50 tons, and the total is 250 tons, including the rudder. The two brackets for the inner shafts are riveted to the main casting by hydraulic power. The brackets for the outer shafts are connected by large flanges to the main structure of the ship. The rudder is in three pieces, apart from the rudder head of forged steel, which is of 25½ inches diameter. The total weight of the rudder is 65 tons.

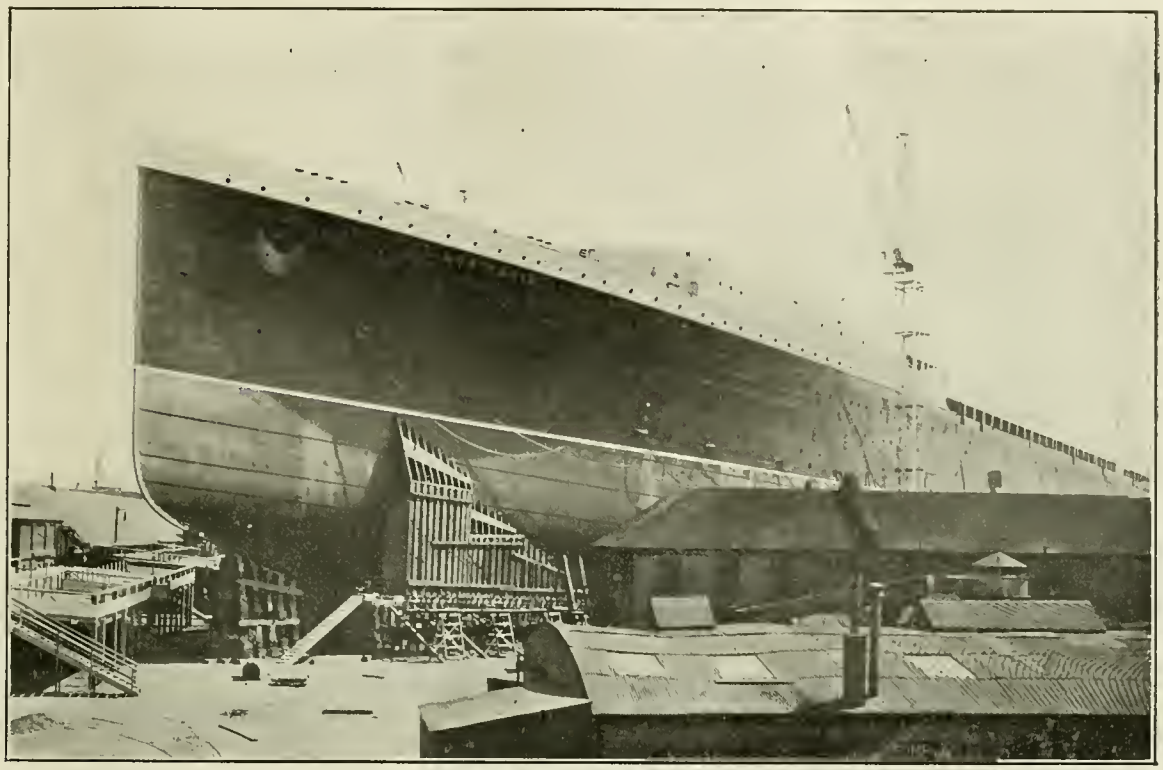
The boilers, 25 in number, are cylindrical, most of them of the double ended type, with eight funaces. The total number of furnaces is 192. These boilers are designed to work under a pressure of 195 pounds per square inch, with the Howden system of forced draught. They are divided into four groups, in four separate stokeholds, and for each stokehold there is an uptake with funnel. The four funnels rise to a height of 154 feet above the keel. Their greatest diameter is 24 feet, and they are oval in shape, so as to reduce the effect of wind pressure. The navigating bridge is 110 feet above the keel, while the masts are 210 feet, or only 56 feet above the tops of the funnels. There are to be two pole masts, to carry the Marconi telegraph gear.



THE NEW CUNARD FLYER ENTERING THE WATERS OF THE CLYDE.

The turbine machinery is very remarkable. There are four shafts, each driving an independent propeller. On the two outer shafts are the high-pressure turbines, taking steam direct from the boilers. After it has passed through these the steam passes to the low-pressure turbines mounted on the inner shafts, and ultimately passes into the condensers. Large turbines for driving the ship astern are on the inner shafts. There are thus six turbines—four for ahead and two for astern motion. The forgings for the shafts and motor drums were made at the works of John Brown and Company at Sheffield. There were also cast the casings which inclose the rotors, with their thousands of blades. These casings are massive pieces of work, the rotor casing and blades of the low-pressure turbines weighing about

450 tons. While the rotor is in one piece the casing requires to be in two pieces, one for the lower part of the circumference and the other for the upper, both being ultimately bolted together to form a complete circle. Around the rotor grooves were turned, into which the actuating blades were secured; and on the inner



BOW VIEW OF NEW CUNARD LINER LUSITANIA ON THE WAYS.

surface of the casing similar grooves were formed for the fixed blades to guide the steam against the moving blades on the rotor. There will be only about one-twentieth part of an inch between the tips of the rotating blades and the surface of the casing, and a similar clearance between the fixed blades on the casing and the surface of the rotor. The speed at the periphery of the circle formed by the blades on the rotor, ranges from 100 to 150 feet per second (68 to 102 miles per hour), so there must be no possible contact between the moving blades and the adjoining surface, yet there must be a minimum space between the blades and the neighboring surfaces, otherwise steam would escape and be wasted.

The blades of the turbines are of brass. Their length increases from the point where the steam from the boiler enters, to the last row, where the steam passes to the condenser. The steam expands continually, and at each row of blades there is a presumed drop in pressure equal to about 1 pound per square inch. Each successive row of blades should be larger than that immediately preceding, but it is found in practice feasible to make five or six rows of the same length. In large turbines such as these, there are nine groups, which successively are of blades of increased length. With fast-running turbines used for driving electric dynamos the blades are very small; but in the *Lusitania*, for the large propellers and running them at low speed, it is necessary to minimize the number of revolutions. Therefore the turbine blades have been fixed at over 20 inches at the low-pressure end of the low-pressure turbine.

The blades of brass were wedged into the grooves formed on the rotor and casing, at right angles to the surface, and in each ring are equi-distant from each other, but to accommodate expansion, the distance between rings increases with their length, so that near the condenser the interval separating the rings attains its greatest width. The blades are bound together by a brass wire tape, which fits into square indents made on the back edge on each blade near the top. This wire is laced with a copper round wire, and the whole is cemented with silver solder. This binding strengthens the long blades. After the blades were put into their grooves in their rotor or casing, and finally secured and bound together, the complete unit was put into a lathe in the case of the rotor, or a boring machine for the casing, to insure that there should not be a greater deviation in length than about the one-thousandth part of an inch, equal length being essential in view of the small clearance between the blades and the surface past which they rotate. The blades are also in perfect alignment, necessitated by the small distance between the edges of the fixed and moving blades. In the larger blades there is a length of edge of quite twenty inches working at a great speed past a corresponding length of fixed blades, and the slightest tendency to rubbing would be disastrous.

A gland packing was devised on a plan to prevent the escape of steam at the end of the turbines, and a system has been perfected for taking up the expansion. The longitudinal adjusting of the rotor within the casing also determines the distance between the edges of the moving and fixed blades. Mr. Parsons devised a system consisting of a "finger plate" secured to the fixed frame of the turbine, which indicates on the rotor shaft the exact clearance permissible, so that the engineer can tell at a glance whether the rotor is in its exact position in relation to the fixed blades in the casing. Screws are provided so that adjustments can be made in the relative position longitudinally of the rotor and casing.

To keep the rotor in a true level in its bearings, and record any tendency to sag, a vertical point is fitted at the end of the casing immediately over the shaft, and by this any change in level of the rotor or shaft, even the thousandth part of an inch, can be detected.

The greater the vacuum the higher the efficiency of the turbine; but as the head of steam and its driving action is opposed to the forward thrust of the propellers, there is not the same

need as with ordinary reciprocating engines for a thrust block to transmit the thrust of the propeller to the ship. In the case of each turbine on the *Lusitania* there is a thrust block for use in starting the machinery, and in changing "ahead" to "astern" motion. In the case of the reversing turbines, the blades are similar to those in the "ahead" turbines, but are mounted with the curve so arranged that the flow of the steam against the concave surface will rotate the shafts and propellers in the stern direction.

The length of ship occupied by machinery, boilers and coal bunkers exceeds 480 feet, and the weight of these items, including water in the boilers, is about 11,000 tons. The total capacity of the bunkers is 6,000 tons of coal, in addition to which provision is made for liquid fuel.

It is too early yet to describe the passenger accommodation and general internal fittings, for these are still *in posse*. But broad features may be named. There are nine decks, including the hold. The upper decks are to be arranged for 550 first-class, 500 second-class and 1,300 third-class passengers. With a crew of about 800, the ship will carry 3,150 souls. The promenading and living spaces for passengers are on a generous scale, the space allowed for each being 50 percent greater than in preceding Atlantic liners. The *Lusitania* will have suites of rooms, single berth cabins, and family suites. The dining arrangements will mark a great advance. In addition to the ordinary dining room there will be a restaurant and a veranda café. The main dining saloon is 125 feet long and 80 feet wide, and seats 500 passengers at once. There will be two passenger elevators, and a complete telephone and electric bell system with a central bureau.

Benjamin Taylor.

Progress of Naval Vessels.

The Bureau of Construction and Repair, Navy Department, reports under date of June 11, 1906, the following percentage of completion of vessels building for the United States Navy:

			May 1	June 1
BATTLESHIPS.				
Nebraska	19 knots.	Moran Brothers Co.	92.65	94.
Georgia	19 "	Bath Iron Works	96.58	96.7
Connecticut	18 "	Navy Yard, New York, N. Y.	97.41	97.41
Vermont	18 "	Fore River Shipbuilding Co.	83.8	85.
Kansas	18 "	New York Shipbuilding Co.	78.5	82.2
Minnesota	18 "	Newport News Co.	88.28	89.76
Mississippi	17 "	Wm. Cramp & Sons	54.88	57.67
Idaho	17 "	Wm. Cramp & Sons	53.52	55.73
New Hampshire	18 "	New York Shipbuilding Co.	42.5	45.7
ARMORED CRUISERS.				
California	22 knots.	Union Iron Works	92.8	93.3
South Dakota	22 "	Union Iron Works	90.4	91.1
Tennessee	22 "	Wm. Cramp & Sons	97.51	98.97
Washington	22 "	New York Shipbuilding Co.	97.3	98.2
North Carolina	22 "	Newport News Co.	42.73	46.35
Montana	22 "	Newport News Co.	38.24	41.32
SEMI-ARMORED CRUISERS.				
St. Louis	22 knots.	Neafie & Levy Co.	95.66	96.78
Milwaukee	22 "	Union Iron Works	94.3	95.2
SCOUT CRUISERS.				
Chester	24 knots.	Bath Iron Works	29.44	32.34
Birmingham	24 "	Fore River Shipbuilding Co.	31.3	34.7
Salem	24 "	Fore River Shipbuilding Co.	32.2	35 7
SUBMARINE TORPEDO BOATS.				
Submarine No. 9		Fore River Shipbuilding Co.	68.2	72.5
" " 10		Fore River Shipbuilding Co.	53 5	57.6
" " 11		Fore River Shipbuilding Co.	60.5	64.1
" " 12		Fore River Shipbuilding Co.	53.8	56.9

The Bureau of Navigation reports that there were constructed in the United States during the month of May 149 sail and steam vessels aggregating 49,137 gross tons. Most of these were very small craft, there being only 14 steam-propelled vessels built of steel. The aggregate tonnage of this last number was 41,332, or an average of 2,952 tons. Five of the ships included in this total are over 6,000 tons each.

TRIAL PERFORMANCE OF UNITED STATES CRUISER ST. LOUIS.

BY L. E. BALDT.

The *St. Louis* is a twin screw protected cruiser, and one of the three vessels of this class authorized by an act of Congress approved June 7, 1900. The contract was awarded to the Neafie and Levy Ship and Engine Building Company of Philadelphia, March 11, 1901. The first keel plate was laid July 31, 1902, and the vessel was launched May 6, 1905. The contract price was $2,740,000, of which $1,500,000 was allotted for the hull and $1,240,000 for machinery. The contract price is exclusive of armor, armament, equipment, etc., which were supplied by the government. The contract speed was to be 22 knots: to be maintained for four consecutive hours, on a mean draught of 22 feet 6 inches, corresponding to a displacement of 9,700 tons.

HULL DATA.

Length between perpendiculars (also L.W.L.)	424 ft. 0	in.
Length over all	426 ft. 6	in.
Breadth molded	65 ft. 1¼	in.
" extreme	66 ft. 0	in.
Depth molded to main deck side at M. S.	40 ft. 2	in.
" " " upper deck side at M. S.	47 ft. 7⅝	in.
Draught, normal, mean	22 ft. 6	in.
Displacement, normal (salt water)	9,663.7	tons
" full load (24 ft. 7 in.) salt water	10,776.5	tons
" per inch at L. W. L. (22 ft. 6 in. draught)	44.92	tons
Area of midship section to L. W. L.	1294.4	sq. ft.
" of L. W. L. plane	18,873.	sq. ft.
" wetted surface to L. W. L.	31,838.	sq. ft.
Centre of gravity of L. W. L. plane aft of M.S.	2.14	ft.
" of buoyancy above bottom of keel	12 ft. 10¼	in.
" " " forward of M. S.	1.03	ft.
Transverse metacenter above centre of buoyancy	14 ft. 0⅜	in.
Longitudinal " " " " "	509 ft. 8⅝	in.
Coefficient of fineness, block	.53	
" " " of M. S.	.87	
" " " of L. W. L. plane	.67	
" " " cylindrical	.61	
Number of frames	114	
" of watertight compartments	186	

THE UPPER DECK.

The upper deck extends from frame 28 forward to frame 87 aft, and is cut away at the corners to give greater arc of fire to the 6-inch guns forward and aft.

The following boats are carried on the upper deck: one 36-foot steam cutter; one 36-foot launch; one 33-foot steam cutter; one 33-foot launch; two 30-foot cutters; two 30-foot whale boats; one 30-foot gig whale boat; six 26-foot cutters; two 20-foot dinghies; one 14-foot dinghy and two 14-foot punts. Four electrically-operated boat cranes are located on this deck, also four electrically-operated deck winches for coaling and general use.

The forward and flying bridges are forward on this deck, and the after bridge at the after end. On the forward bridge is a chart house fitted for the use of the navigator, and just beneath it on the upper deck is the day cabin for the commanding officer. On the after bridge is the wireless telegraph house. Twelve 3-inch rapid fire guns, two one-pounder, and two automatic .30 calibre guns are on this deck.

THE MAIN DECK.

The main deck is the first of the continuous decks extending the whole length of the ship. Forward on this deck are two electrically-operated deck winches for anchor work, coaling and general uses. Within the superstructure are the berthing space for the crew, hammock nettings, bakery, galleys, executive

navigator's and paymaster's offices. Aft, outside of the superstructure, is located one electrically-operated winch for general service. There are six 6-inch and six 3-inch guns on the main deck.

GUN DECK.

Forward of the casemate, on this deck, are the crew's showers, water closets and berthing space and laundry. Aft of the casemate are the armory, officers' lavoratories, wardroom officers' rooms and mess room, captain's office, pantry and cabins. On this deck there are eight 6-inch guns, twelve 3-inch guns and two 1-pounder rapid-fire guns.

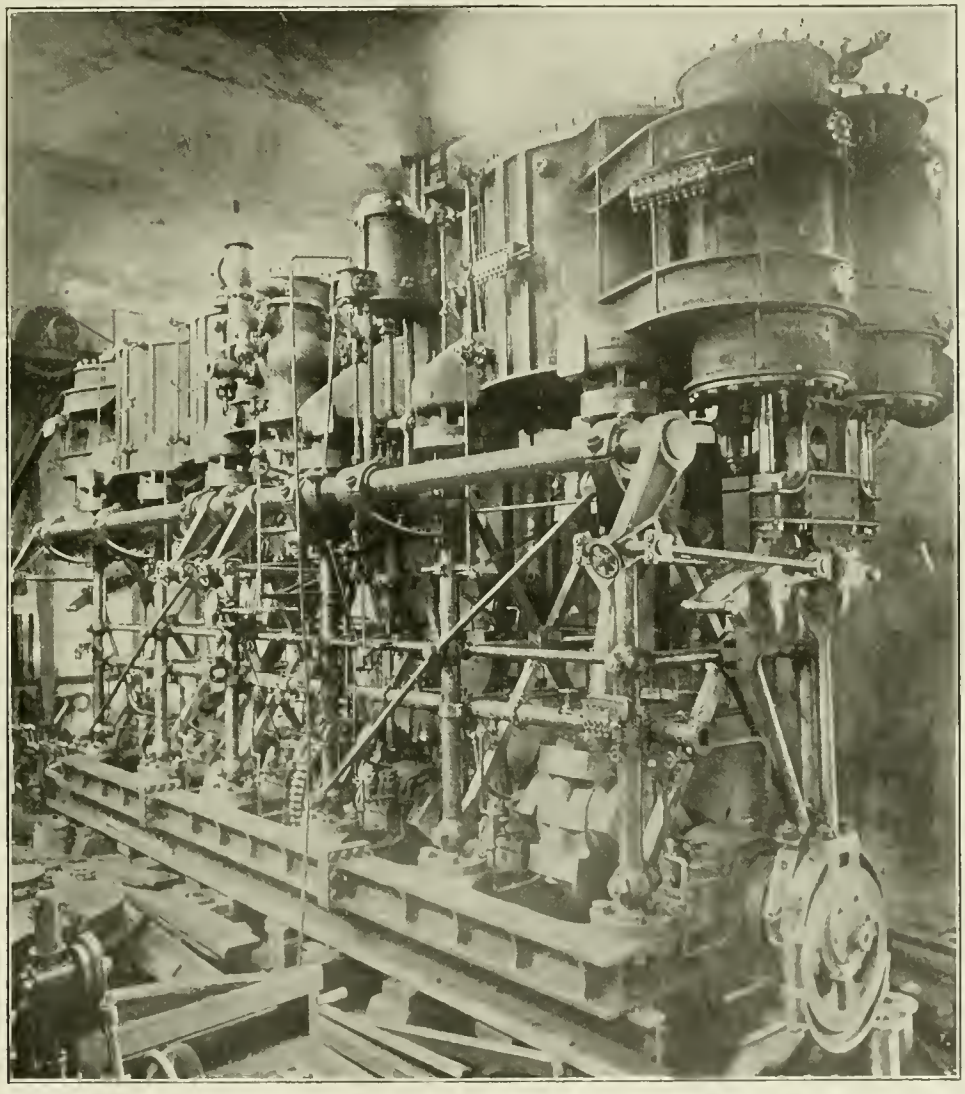
BATTERY.

The main battery consists of fourteen 6-inch rapid-fire rifles, 50 calibres in length The secondary battery consists of eighteen 3-inch rapid-fire guns, 50 calibres in length; twelve 3-pounder semi-automatic guns, four 1-pounder heavy automatic guns; two machine guns, .30-calibre, and eight automatic guns, .30-calibre.

EQUIPMENT.

Electric Plant.—There are two 100-kilowatt, and three 50-kilowatt generating sets of 125 volts pressure at the terminals, furnished by the Sturtevant Company. The engines are of the vertical cross-compound type, and for the 50-kilowatt sets have cylinders 7½ and 14 inches in diameter by 8 inches stroke. For the 100-kilowatt sets the cylinders are 9½ and 18 inches in diameter by 10 inches stroke. The dynamos are of the direct current compound wound multipolar type, and the wiring is arranged on the two-wire feed system. There are about 1000 incandescent lamps, 12 inclosed arc lamps, six 30-inch search lights, two electric night signalling sets, two truck lights and two diving lanterns with 150-candle power lamps, 40 desk and bracket ventilating fans.

Anchor Windlass.—A Hyde anchor windlass is located forward in a pocket between the main and gun decks. The windlass engine is on the gun deck just forward of the windlass pocket, and is a two-cylinder, vertical, inverted, reversible engine, having two 15-inch cylinders of 14-inch stroke.



PORT ENGINE OF CRUISER SAINT LOUIS, ERECTED IN SHOP.

THE BERTH DECK.

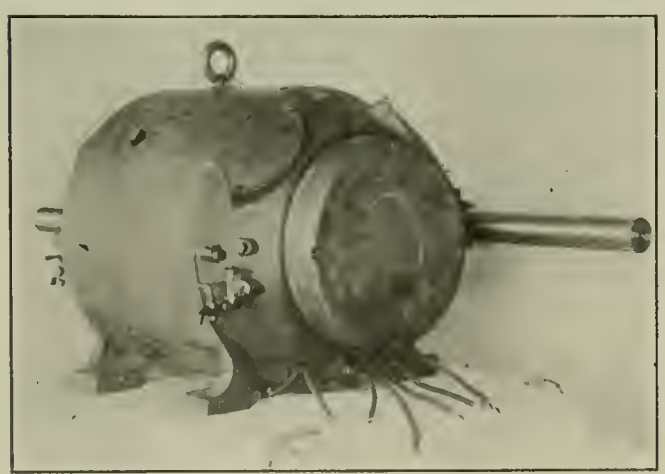
Forward on this deck are paints and oils, prisons, band room, isolated ward, sick-bay, dispensary, crew's berthing space, chief machinist's and chief petty officers' quarters and lavatories, blacksmith shop, firemen's and servants' wash rooms. Aft are junior and warrant officers' staterooms and mess rooms and wardroom state rooms. The evaporator room, ice machine and refrigerating rooms, and store rooms are located on this deck.

The protective deck extends the whole length of the vessel, and its level corresponds with that of the berth deck. The upper platforms are below the protective deck, and are arranged for stores, magazines, ammunition passages, upper dynamo room, steering gear, etc. The lower platforms are below the upper platforms, and arranged for stores, magazines, etc.

Steering Engine.—A Hyde combined steam and hand steering engine is located on the upper platform deck, aft of bulkhead on frame 102. The engine is two-cylinder, horizontal, direct acting, with two 16-inch cylinders of 12-inch stroke. Steering stations are located on flying bridge, pilot house, conning tower, communication room on upper platform deck forward, steering gear room, and steering room on upper platform deck aft.

Winches.—There are seven 25-horsepower electrically driven deck winches, four of which are located on the upper deck, two forward on the main deck and one aft on the main deck.

Ammunition Hoists.—There are 27 electrically operated ammunition hoists fitted to furnish ammunition to the battery. The motors are reversible and operate at about 1000 R. P. M. Frictional slip gears are provided between the motors and the hoists to prevent damage being done in case of sudden stoppage of the hoists. Stops are fitted to prevent ammunition from falling back in the hoists.

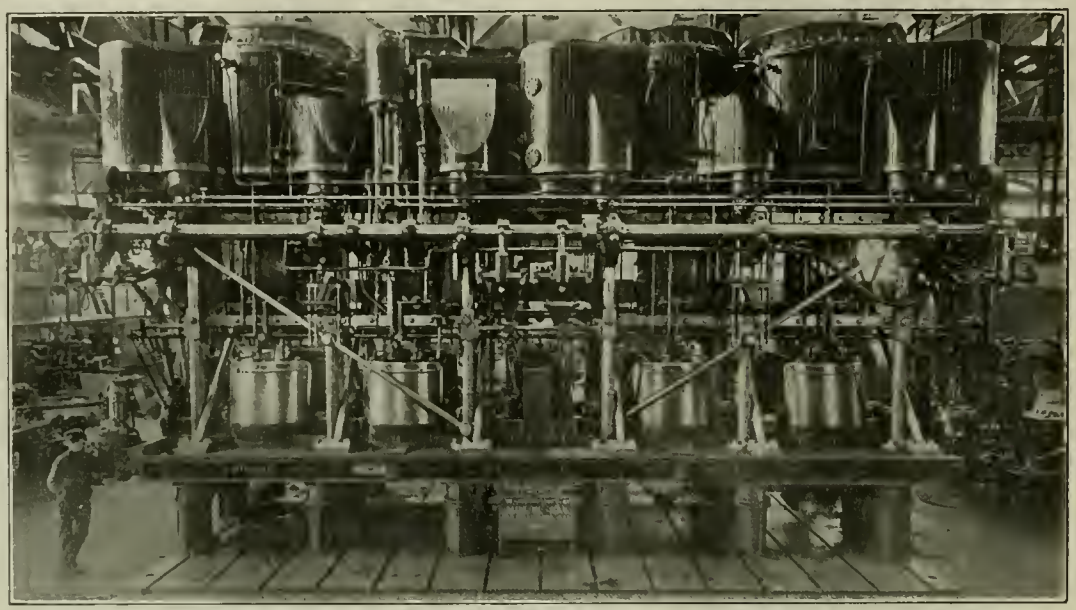


STURTEVANT MOTOR FOR AMMUNITION HOIST.

Ground Tackle.—The following anchors are supplied: two bower anchors, National patent type; one sheet anchor, Navy type; one stern anchor, Navy type; one stream anchor, Navy type; two kedge anchors, Navy type; eighteen boat anchors, two buoy anchors.

PROPELLING MACHINERY.

There are two main engines placed abreast, in separate watertight compartments, with a communicating door in the center-line bulkhead between the two engine rooms. The engines are of the four-cylinder, vertical, inverted, direct-acting, triple-expansion type, and designed to indicate 21,000 horsepower at about 133 revolutions per minute, with a steam pressure of 250 pounds at the high-pressure cylinder, and arranged for inboard turning screws. The order of the cylinders, beginning forward, is: forward L. P., H. P., I. P., and after L. P. The forward L. P. and H. P. cylinders are rigidly bolted together, also the I. P. and after L. P. cylinders. Facings, however, are left on the after side of high-pressure cylinders fitting removable guides on intermediate cylinder casings, to prevent side motion, and at the same time to allow for expansion in a fore and aft direction.



ENGINE OF THE CRUISER MILWAUKEE, SISTER TO THE ST. LOUIS.

(Photograph, 1905, H. W. Jumper)

All cylinders are of cast iron and are steam jacketed around the working liners. The heads of the intermediate and low-pressure cylinders are also jacketed.

The cylinders, for each engine, are supported by twelve forged-steel columns, flanged at top and bottom, for bolting to cylinders and bed plates. For each athwartship pair of columns there are two diagonal braces, rectangular in section, forming an X-brace. The outer ends are tongued and fitted to grooves at top and foot of columns and bolted. The two braces are secured together at their centers by two keys, also by a horizontal athwartship tie-rod passing through columns and braces, with sleeve distance pieces. The framing is further stiffened by fore and aft horizontal and diagonal tie rods secured to columns. There are two cast steel strong backs bolted to outboard row of columns, to which the crosshead guides are bolted.

The athwartship tie rods that are usually fitted between the main engine cylinders of opposite engines on naval vessels of this size were omitted, and it was found after trial they were not necessary, for the vibration of engines at all speeds was not excessive.

The bed plates are steel castings, each in three sections, and securely bolted together. Each section has two longitudinal girders and two cross girders, all of I section, stiffened by ribs, and finished for crank-shaft bearings, columns and turning engine. The bed plates are bolted to the engine keelsons by body-bound bolts, with steel washers fitted at each holding-down bolt between bed plate and engine keelson. Yellow pine strips are fitted between the washers.

The high-pressure steam pistons are made of cast iron, the intermediate and low-pressure pistons of cast steel, conical in shape, and finished all over. Wrought steel followers hold in place hard cast iron packing rings, one wide ring being fitted in each high and intermediate pressure piston, and two narrow rings in the low-pressure pistons. The piston rods are made of forged nickel-steel, oil-tempered and annealed, with bored axial holes the entire length. The rods are accurately ground and polished to an outside diameter of 8 inches.

The crossheads are made of forged steel. The pins extend on each side of the crosshead and are forged in one piece with it. The slippers are cast steel, bolted to the outboard side of the crosshead, and the sliding surfaces are faced with navy standard white metal.

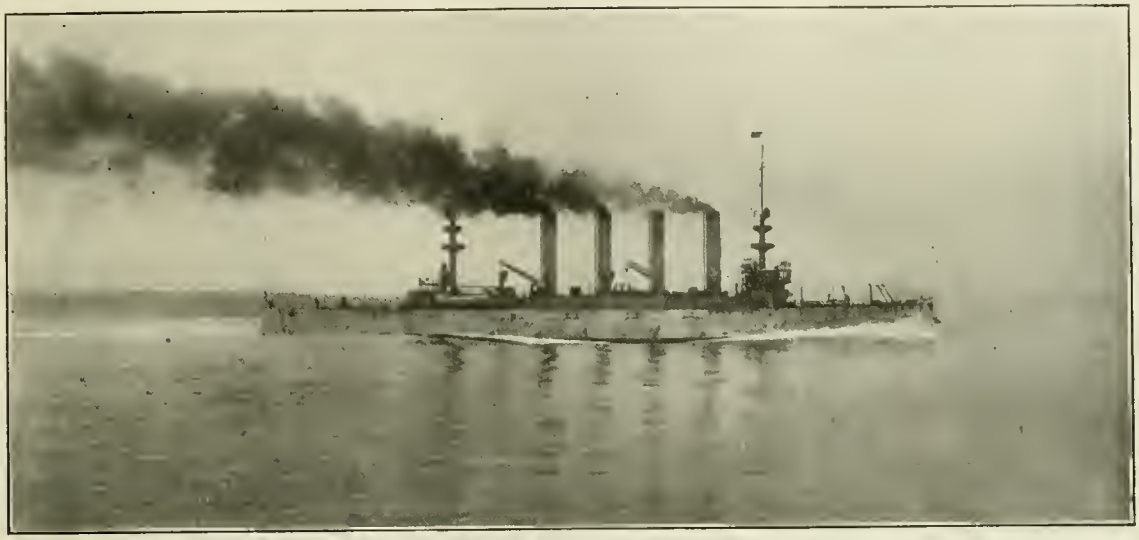
Cast iron crosshead guides, made hollow for the circulation of cooling water, are bolted to the cast steel strong backs on the back engine columns, and at their tops to the cylinder casings. The backing guides are also made of cast iron, and bolted to flanges on the go-ahead guides.

The connecting rods are of forged nickel-steel, oil-tempered and annealed, with axial holes the entire length. The upper ends are forked to span the crossheads, and carry the crosshead pin brasses. Both the crosshead and crank-pin brasses are lined with navy standard white metal.

The valve chest of each high-pressure cylinder is fitted with one, and the intermediate and low-pressure cylinders with two, single-ported piston valves. The valves are cast iron, made hollow for the passage of steam to the ends of the valve chest, and are all provided with balance pistons, the cylinders of which form part of the upper covers of the valve chests. Each end of the piston valves is fitted with a single cast-iron packing ring, held in place by a forged steel follower, and made to permit of contraction but not expansion. The piston valves for all cylinders are operated by the Stephenson double-bar link motion with adjustable cut-off.

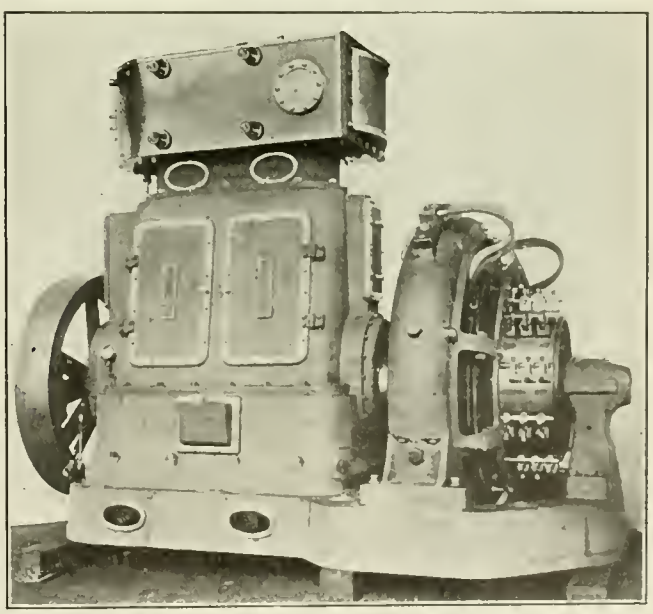
The eccentrics are made in two parts, the larger part being made of cast iron, the smaller of forged steel, and secured together by 2-inch steel bolts. Each backing eccentric is rigidly keyed to the crank shaft, and the go-ahead eccentric is secured to the shaft by a key, with adjusting pieces between the key and eccentric. The eccentric straps are composition, lined with white metal. The eccentric rods are nickel-steel with forked upper ends to span the links, and T-heads at lower end for bolting to eccentric straps. The main links are nickel-steel, double-bar, with pins forged on for drag links and eccentric rods. The link blocks are also nickel-steel, and are fitted with adjustable composition gibs.

There is a 14-inch balanced throttle valve fitted on each engine, balanced by piston working in a cylinder forming a part of the throttle-valve casing, steam being admitted to the back of the balance piston. To further insure ease in closing, a toggle gear is fitted to valve stem.



UNITED STATES ARMORED CRUISER SAINT LOUIS ON OFFICIAL TRIAL TRIP.
(Copyright, 1906, N. L. Stebbins, Boston.)

The crank, line, thrust, propeller and stern-tube shafts are forged nickel-steel with axial holes their entire length. The crank shafts for each engine are made in two sections, with two cranks on each section, placed opposite each other. The forward low-pressure and high-pressure cranks are opposite; also the intermediate-pressure and after low-pressure cranks; the second pair being at right angles with the first, and the sequence of the cranks being high, intermediate, forward low-pressure, and after low-pressure. Each complete crank shaft has six main bearings, each thrust shaft two steady bearings, and each line shaft one steady bearing. Each stern-tube shaft is supported by bearings



ONE OF THE ELECTRIC GENERATING SETS.

at each end of stern-tube, and each propeller shaft has one strut bearing. The stern-tube and strut bearings are lined with lignum-vitæ, end grain exposed, while the main and steady bearings are lined with white metal.

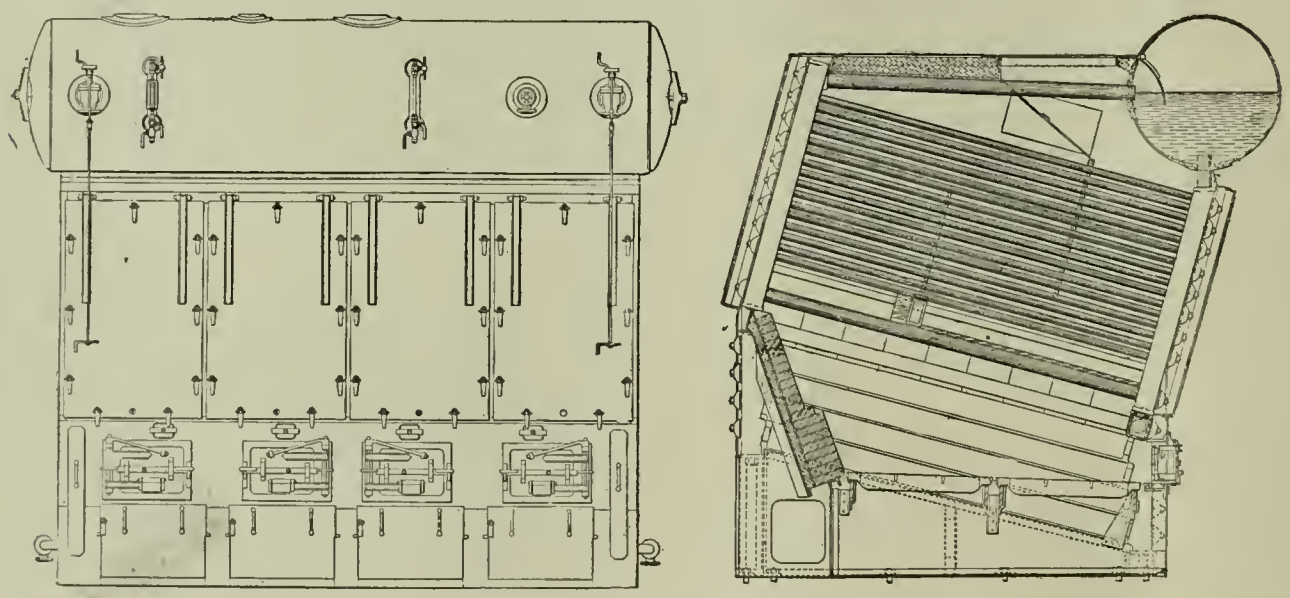
The thrust bearing is of the horseshoe type. The body is of cast iron, and the horseshoes cast steel. The end and side walls of the body form an oil reservoir, in which the lower part of the collars turn. The reservoir is fitted with a circulating coil for cooling water. The horseshoes are made hollow for the circulation of cooling water, and faced with white metal.

The outboard coupling connecting stern-tube and propeller shafts consists of a forged steel sleeve, bored taper for ends of shafts, and secured by longitudinal and cross keys. The coupling connecting the stern-tube and line shafts consists of a collar securely keyed to forward end of stern tube shaft by four keys. Aft of this collar another collar of the same diameter, made in halves, is secured to the forward collar and to the after coupling flange of the line shafts by eight 3 9/16-inch fitted bolts.

The turning engine is a double-cylinder, inverted engine, secured to the outboard side of the main engine bed plates and connected by worm gearing to the crank shaft. The cylinders are 6 inches in diameter and 6 inches stroke. A ratchet is fitted for hand turning.

The maneuvering of the main engines is controlled by a vertical steam reversing engine, bolted to the front of each engine, of the floating lever type, and with an oil-controlling cylinder. The reversing shaft is carried in bearing brackets bolted to front

F. L. P., diameter, inches	5
A. L. P., diameter, inches	4
Connecting rods, length center to center, inches	90
diameter, upper end, inches	8⅛
diameter, lower end, inches	9⅜
axial hole, H. P., diameter, inches	1½
I. P., diameter, inches	3
L. P., diameter, inches	5
Crank shafts, diameter, inches	18
axial hole, diameter, inches	11½
coupling flange, diameter, inches	32
coupling flange, thickness, inches	3¾
coupling bolts (8) diameter, inches	3 9/16
journals, diameter, inches	18
(2) lengths, inches	32¾
(2) lengths, inches	22½
(1) length, inches	31
(1) length, inches	27¾
length over all, feet and inches	35-3
Crank pins, diameter, inches	18½
length, inches	22
diameter of axial hole, inches	12
webs, width, inches	20
thickness, inches	17¼
Crosshead pins, diameter, inches	10¼
length (each side of crosshead), inches	10¾
axial hole, H. P., diameter, inches	1½



LAYOUT OF ONE OF THE BABCOCK AND WILCOX WATER TUBE BOILERS.

engine columns. The shaft is provided with an arm for each link, with independent adjustable cut-off blocks.

A complete oil and water system is provided, extending to all parts of the main engines.

MAIN ENGINE DATA.

Cylinders; high-pressure, diameter, inches	36
intermediate-pressure, diameter, inches	59½
low-pressure (2), diameter, inches	69
Stroke of all pistons, inches	45
Piston valves, high-pressure, diameter, inches	22
intermediate-pressure, diameter, inches	25½
low-pressure, diameter, inches	25½
Cylinder ratios 1 : 2.73 : 7.34	
Main steam pipe, diameter at throttle, inches	14
Exhaust pipe to condenser, diameter, inches	27
Piston rods, diameter, inches	8
axial hole, H. P., diameter, inches	1½
I. P., diameter, inches	4
I. P. and L. P., taper, diameter, inches	6 to 2
Crossheads, wearing surface, ahead, square inches	732
backing, square inches	274.5
Thrust shaft, diameter, inches	17¼
axial hole, diameter, inches	11½
collars, number, each shaft	13
diameter, inches	25¼
thickness, inches	2
space between, inches	4
length, feet and inches	12-6
Line shaft, diameter, inches	17
axial hole, inches	11½
length, feet	22
coupling flange, diameter, inches	32
thickness, inches	3¾
bolts (8), diameter, inches	3 9/16
Stern tube shaft, diameter, inches	18
axial hole, diameter, inches	11
length, feet and inches	32-8⅜

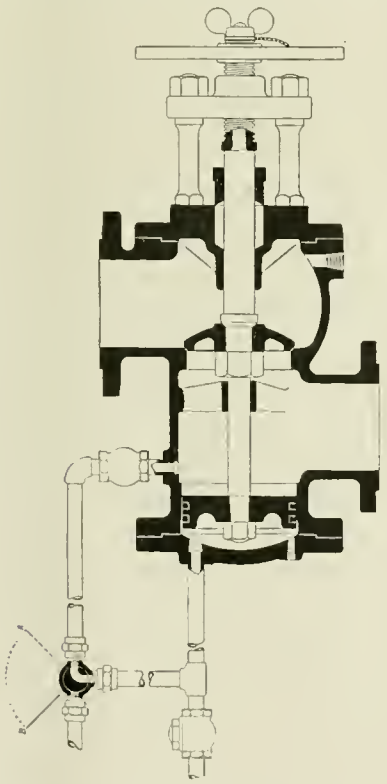
Propeller shaft, diameter, inches	18
axial hole, diameter, inches	11
length, feet and inches	36-5

BOILERS.

There are sixteen Babcock and Wilcox water tube boilers, placed in four water-tight compartments, and designed for a working pressure of 265 pounds per square inch.

Steam drum, inside diameter	42 ins.
thickness	21/32 ins.
Grate, length	7 ft. 0 ins.
width	12 ft. 6 ins.
surface, one boiler	87.5 square feet.
all boilers	1,400 square feet.
Heating surface, one boiler	4,000 square feet.
all boilers	64,000 square feet.
Ratio of grate surface to heating surface	45.71
Elements, one boiler (21 intermediates, 2 sides)	23
Tubes, one boiler, 2-inch, No. 8 B. W. G., 9 ft. 2 ins. long.	722
4-inch, No. 6, B. W. G., 9 ft. 2 ins. long..	23
4-inch, No. 6, B. W. G., 7 ft. 3 ins. long..	23
Safety valves (1 triple-type each boiler), total	48
diameter of each valve	3 ins.
Smoke pipes (4), diameter, inside	8 ft. 0 ins.
cross sectional area, each	50.265 sq. ft.
total	201.06 sq. ft.
height above grates	92 ft. 6 ins.

Boiler Stop Valves.—The boiler stop valves are the invention of Commander A. B. Willitts, United States Navy. These valves are steam opening as well as steam closing. Heretofore, steam

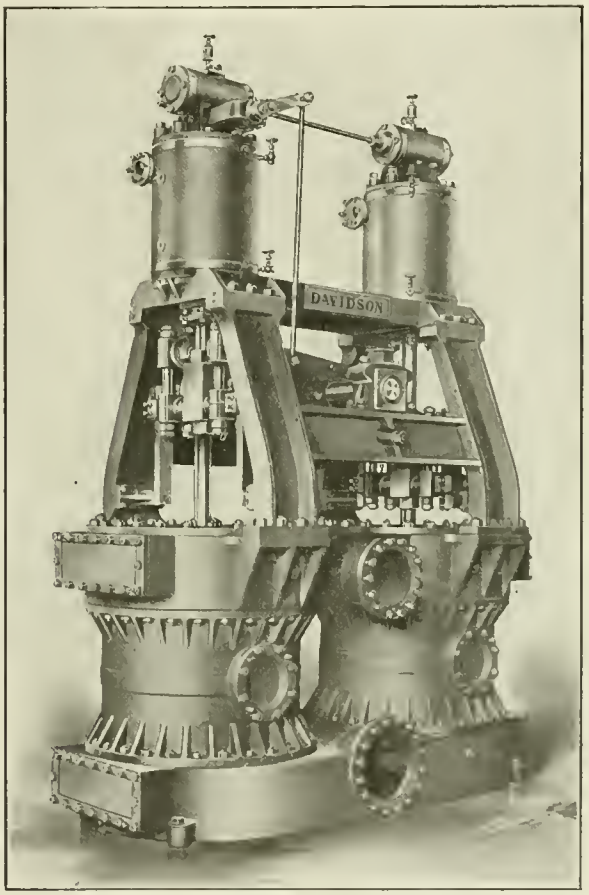


WILLITTS STOP VALVE.

closing valves have been designed with a steam cylinder separate from the valve chamber, and in which steam was used for closing the valve only. Two stuffing boxes were necessary, and the keeping of these tight was an added difficulty. The Willitts valve carries the valve and actuating piston in the same chamber. The two-way operating cock shown in cut, for steam opening and closing of these valves, is located in the next compartment aft the one containing said set, each boiler having its own separate and independent cock. These valves have worked satisfactorily in all respects.

Mode of Operation.—As a hand-operated valve its functions are obvious and need no extended description.

As a steam opening and closing stop or throttle valve the hand nut on the end of the valve stem is unscrewed entirely from the threaded end (as it always is when the valve is in service), but is left attached by a chain, to prevent its becoming lost or mislaid; the screw sleeve is backed from the valve stem shoulder, by means of the hand wheel, sufficiently to permit the valve disk to raise to its "full open" position. Then, to open the valve, the lever of the two-way cock is slowly moved, so as to admit steam from the valve chamber into the chamber at outer end of piston and balance the unit pressure on both sides of the piston. The greater force from the total pressure on the piston being on the outside (owing to the area of the stem), this difference, together with the pressure on the under side of the valve disk, unseats the latter and opens the valve.



ONE OF THE MAIN AIR PUMPS ON THE ST. LOUIS.

To close the valve the lever of the two-way cock is moved to a position which closes the communication between the two chambers and opens the chamber at the outer end of the piston to the atmosphere and releases the pressure on the outside of the piston. The area of this piston on the valve side, being greater than the area of the valve disk, causes the piston to move outward and bring the valve disk to its seat and thus close the valve. It is obvious that the rapidity with which the lever of the two-way cock is moved determines the rapidity of motion of the valve disk. The connections of the pipes are preferably so made that the chamber at the outer end of the piston becomes filled with water of condensation, the inflow and outflow of which will control more rigidly the movement of the piston, and also hold the valve disk from chattering on its seat when but little steam is flowing through the valve.

AUXILIARY MACHINERY.

Main Condensers.—There is one main condenser located on the outboard side of each engine room. The shell plating is steel boiler plate, the heads composition, tube sheets of rolled Muntz metal, and tubes seamless drawn and of a mixture 70 copper, 29 zinc, 1 tin. The forward head, being the one for the entrance and exit of circulating water, has a division plate fitted with valves which, when open, allow the circulating water to pass overboard direct when pumping from the bilge. These valves are operated by a lever on the outside of the condenser. Baffle plates are fitted to direct the steam over all the tubes. The ratio of total cooling surface to total heating surface is 1 to 2.38.

Diameter of shell, inside	7 ft. 0 ins.
Thickness of shell	⅜ inch.
Tubes, diameter, outside	⅝ inch.
thickness, No. 18 B. W. G.	0.049 inch.
length between tube sheets	14 ft. 4 ins.
number in each condenser	5,714
Cooling surface, square feet, each	13,400
square feet, total	26,800

Main Air Pumps.—There is one double, vertical-beam, single-acting Davidson air pump, with two inverted steam cylinders, for each main engine. Each air-pump bucket contains 18 5-inch valves built up of three flat disks of rolled manganese bronze plates 1/32-inch thick. The suction and discharge valve decks each contains 20 similar valves.

Diameter of steam cylinders, each	14 ins.
water cylinders, each	33½ ins.
Stroke	18 ins.
Diameter suction nozzle	12½ ins.
discharge nozzle	10 ins.

Main Circulating Pumps.—To furnish cooling water for each main condenser there is one double-inlet, centrifugal, circulating pump, driven by a vertical, compound engine with cranks at right angles. Each pump is fitted to draw from the sea, the main drain, and the engine-room bilge. These three suction valves are interlocked in such a way that only one can be opened at a time. Each of these pumps is capable of discharging 12,000 gallons per minute from the bilge.

Diameter of steam cylinders	10 and 18 ins.
Stroke	9 ins.
Diameter of pump runner	48 ins.
Width of runner at periphery	5¾ ins.
Diameter of inlet nozzle	20½ ins.
outlet nozzle	20½ ins.

Feed and Filter Tanks.—There is a feed and filter tank of 5,000 gallons capacity in each engine room. The forward end of each tank is arranged as a filter chamber, loufa being the filtering material used. The tanks are covered with hair felt and lagged with galvanized iron.

Feed Pumps.—There are four main and four auxiliary feed pumps, of the Davidson vertical, double-acting plunger type, all of the same size, 14 inches by 10 inches by 15 inches. The main feed pumps are located in the engine rooms, and draw from the main feed tanks, and deliver into the main feed pipes, either through the feed water heaters, or by by-passing. One auxiliary feed pump is located in each fire room, and arranged to draw from the feed tanks in the engine rooms, from the auxiliary drain, from the sea, from the fire room bilge of its own compartment, and from the bottom blow pipes of all boilers in its own compartment. Each delivers into a fore-and-aft feed main leading to all boilers on its own side of the ship, into the fire main, and overboard through a sea valve in its own compartment.

Feed Water Heaters.—There is one feed water heater in each engine room, located on the discharge side of the main feed pumps, well up under the protective deck. The feed water passes through the tubes, and the (heating agent) exhaust steam from the auxiliary exhaust line passes around the tubes

DATA FROM STANDARDIZATION RUNS OF U. S. S. ST. LOUIS ON MEASURED MILE OFF ROCKLAND, MAINE, MAY 16, 1906.

Number and Direction of Run	Time on Course Min.	Time on Course Sec.	Which Engine	Revs. of Main Engines To Make One Knot	Revs. of Main Engines Per Minute	Revs. of Main Engines Average	Speed in Knots	Indicated Horsepower Main Engines H. P. Cyl.	I. P. Cyl.	F. L. P. Cyl.	A. L. P. Cyl.	Total	Total Both Engines	Auxiliaries in Operation	Total All Machinery	Steam Pressures In Boilers	Gauge At Engine	Absolute H. P. St'm Chest	Absolute 1st Rec'r	Absolute 2nd Rec'r	Mean Effective Pressure H. P. Cyl.	I. P. Cyl.	F. L. P. Cyl.	A. L. P. Cyl.	Referred to I. P. Cyls.	Vacuum in Inches	Air Pressure in Inches of Water	Cut-off in Cylinders H. P.	I. P.	F. L. P.	A. L. P.
1-S	2 41.9		S	410.65	158.43	151.74	21.236	4023.8	3818.1	2830.6	2805.0	13477.5	27047.0	368.4	27385.4	269	260	265	110	43	117	40	22	21.8	52.38	27	1.50	Full Gear	Full Gear	Full Gear	Full Gear
			P	407.45	151.24			4026.5	3883.0	2868.6	2821.4	13539.5					265		112	43	118	41	22	22.1	53.03	27.5					
2-N	2 43.05		S	410.20	150.90	150.43	22.079	4017.5	3638.1	2776.8	2802.2	13234.6	26864.6	449.2	27313.8	271	245	250	103	41	118	38.5	22	21.8	51.95	27.5	1.56				
			P	407.60	149.95			4126.1	4037.7	2784.6	2784.6	13630.0					250	253	110	42	119	43	22	22	53.85	27.5					
3-N	2 45.75		S	409.30	148.57	147.79	21.719	3787.8	3535.3	2721.4	2784.0	12828.5	25418.4	485.9	25904.3	261	240	245	100	42	113	38	22.2	21.7	51.15	27.5	1.60				
			P	405.00	147.01			3582.2	3520.5	2630.8	2556.4	12289.9					240	240	105	40	108	41.5	20.6	21.2	50.72	27.5					
4-S	2 40.55		S	408.50	152.81	152.17	22.423	3880.0	3827.6	2876.4	3057.0	13650.0	27502.8	475.4	27978.2	275	250	255	105	45	112.8	40	22.3	23.7	52.91	27	1.52				
			P	405.05	151.52			3931.5	4127.5	2941.7	2852.1	13852.8					255	260	115	45	115	43.5	23	22.3	54.16	27.5					
5-N	2 41.40		S	412.25	154.25	152.66	22.395	4126.9	3933.4	2974.3	3155.3	14089.9	28085.4	473.0	28558.4	277	250	255	110	45	116.5	41	23	24.4	54.48	27	1.68				
			P	409.05	152.06			4048.0	4094.5	3054.9	2708.1	13995.5					255	260	110	44	118	43	23.8	21.8	54.52	27.5					
6-S	2 45.20		S	402.60	146.40	146.17	21.792	3468.2	3346.1	2496.3	2644.5	11955.1	24216.4	462.6	24679.0	276	250	260	95	40	105	36.5	20.2	21.4	48.37	27	1.50				
			P	401.30	145.93			3157.2	3602.0	2623.8	2488.3	12261.3					240	240	100	39	105	40.4	21.3	20.2	49.77	27.5					
7-N	2 58.15		S	409.70	137.87	136.53	20.208	3141.7	2823.2	1978.4	2187.9	10131.2	19426.8	381.6	19808.4	274	260	265	80	35	101	32.7	17	18.8	43.53	27	1.00				
			P	401.70	135.18			2897.5	2666.6	1905.7	1825.8	9295.6					260	265	77	30	95	31.5	16.7	16	40.73	27.5					
8-S	2 53.6		S	401.05	138.61	136.95	20.737	3002.2	2864.3	2106.0	2199.6	10172.1	19266.8	351.0	19617.8	260	250	255	80	35	96	33	18	18.9	41.47	27.5	.80				
			P	391.40	135.28			2777.5	2651.6	1884.2	1781.4	9094.7					255	260	78	30	91	31.3	16.5	15.6	39.82	27.5					
9-N	3-2.55		S	401.05	131.89	130.95	19.721	2559.1	2229.9	1658.8	1736.7	8184.5	17248.2	318.9	17567.1	276	260	260	66	29	86	27	14.9	15.6	36.76	27.5	.80				
			P	403.95	132.84			2847.3	2661.9	1827.7	1726.8	9063.7					260	267	79	30	95	32	16.3	15.4	40.42	27.5					
10-S	3-1.50		S	387.40	128.07	127.65	19.835	2485.0	1972.9	1416.2	1545.9	7420.0	15009.5	335.1	15344.6	261	250	255	80	26	86	24.6	14.3	13.1	34.31	27.5	.60				
			P	384.85	127.23			2353.9	2207.0	1535.8	1492.8	7589.5					255	260	82	26	82	27.7	14.3	13.9	35.33	27.5					
11-N	3-10.40		S	392.90	123.81	124.06	18.908	2151.0	1705.7	1264.6	1379.5	6500.8	13407.9	311.2	13719.1	273	260	265	77	24	81.5	22	12.1	13.2	31.10	27.5	.35				
			P	394.45	124.31			2285.9	2008.4	1332.6	1280.2	6907.1					265	265	83	24	81.4	25.8	12.7	12.2	32.91	27.5					
12-S	3 9.95		S	380.75	120.40	120.43	18.952	1774.4	1583.3	1138.3	1158.6	5754.6	11868.5	297.1	12165.6	278	265	275	144	21	69	21	11.2	11.4	28.31	27.5	.40				
			P	380.95	120.46			2106.4	1750.1	1138.9	1118.5	6113.9					275	275	155	21	77.5	23.2	11.2	11	30.07	27.5					
13-S	3 24.05		S	393.55	115.73	115.46	17.643	1644.9	1340.7	976.0	1025.7	4988.2	10185.6	291.5	10477.1	267	260	265	130	19	63	18.5	10	10.5	25.53	27.5	.35				
			P	391.70	115.18			1514.7	1884.1	894.4	904.2	5197.4					260	265	139	19	72.5	21	9.2	9.3	26.73	27.5					
14-S	3-27.4		S	380.85	110.18	109.84	17.258	1342.4	1110.8	874.2	883.5	4210.9	8469.1	270.5	8769.6	264	255	255	115	17	54	16.1	9.4	9.5	22.64	27.5					
			P	378.50	109.50			1457.6	1268.5	785.7	776.4	4288.2					260	260	122	17	59	18.5	8.5	8.4	23.20	27.5					

and drains to the main and auxiliary condensers and feed tanks.

Diameter of copper shell (inside)	35 inches.
Thickness	5/16 inch.
Tubes, number, one heater	976
diameter, outside	⅝ inch.
thickness	No. 14 B. W. G.
length between tube sheets	6 ft. 0 ins.
Total heating surface (958 sq. ft. each)	1,916 sq. ft.

Auxiliary Condensers.—There is an auxiliary condenser, with combined horizontal air and circulating pump, in each engine room. Each condenser has a cooling surface of 620 square feet. The air and circulating pump has dimensions of 7 inches by 8 inches by 12 inches by 7 inches. There is one auxiliary condenser in lower dynamo room, with a cooling surface of 1,214 square feet. The dimensions of air and circulating pump are 10 inches by 12 inches by 16 inches by 12 inches.

Forced Draft.—The closed fire-room system of forced draft is used. The blowers, eight in number, are of the Sturtevant type, and are located on the protective deck under the breeches portion of the smoke pipes, two for each fire room. The fans are 69 inches in diameter; width of rim at periphery 25 inches. The fans are driven by double upright inclosed engines; cylinders 7 inches diameter by 5-inch stroke.

Hot Well Pumps.—There is one Davidson vertical, single-cylinder hot-well pump, 12 inches by 14 inches by 12 inches, in each engine room. These pumps draw from the main feed tanks, main air pump suction pipes, reserve feed tanks, and from the ship's side above the water line for taking in fresh water, and discharge into the main feed tanks and reserve feed tanks.

Fire and Bilge Pumps.—There is one Davidson fire and bilge pump, of the same size and type as the hot-well pumps, in each engine room. These pumps draw from the sea, the auxiliary drain, the drainage manifolds, the engine-room bilge and crank pits. Discharges overboard and to fire main.

Ash Hoists.—A Williamson ash hoisting engine is located in each fire room hatch inclosure at the main deck level, and operated by means of hand wheels and geared shafting from the hoisting station. From the hoisting stations, the ash buckets are carried by trolley tracks to the ash chutes at the ship's side.

Distilling Apparatus.—The distilling plant consists of four evaporators and six distillers, with their accessories. The evaporators are of the navy type and were designed to have a combined capacity of 21,000 gallons of water per 24 hours. The distillers are vertical, with straight tubes, designed to distil 20,000 gallons of potable water in 24 hours. The test of the plant showed a capacity considerably in excess of the design.

Refrigerating Plant.—One Allen horizontal, dense air ice machine, capable of producing the cooling effect of two tons of ice in 24 hours, supplies cold air to the cold storage rooms, ice-making tank, and scuttle butt.

Engineers' Workshop.—A well arranged workshop is located on the port side of the berth deck abreast of the engine hatch inclosure. A 10-horsepower electric motor drives the following tools:

One 30-inch back-geared, screw-cutting lathe; one 14-inch back-geared screw-cutting lathe, one 16 by 24-inch column shaper, one back-geared drilling machine, one 16-inch sensitive drill, one No. 1 universal milling machine, and one emery grinder.

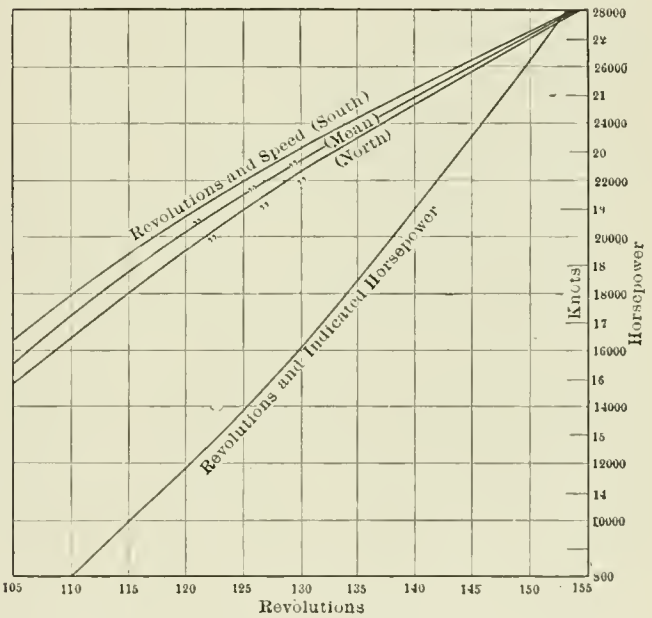
SCREW PROPELLERS.

The propellers have each three blades, adjustable pitch, and are made of manganese bronze. The blades are bolted to the hubs by rolled manganese bronze tap bolts, and secured by lock plates. The blades, hubs and caps are finished smooth and burnished.

Diameter of propeller, feet	18
Diameter of hub, feet and inches	4-7½
Length of hub, inches	45
Pitch of starboard propeller, feet and inches	19-5
Pitch of port propeller, feet and inches	19-4.22
Pitch ratio, mean	1.077
Helicoidal area, each, square feet	91.5
Disk area, each, square feet	231.9
Projected area, each, square feet	76.74
ratio to disk area	0.331

DATA FOR FOUR HOURS' TRIAL.

	Starb.	Port.
Steam pressure at boilers (gauge)	266	
H. P. steam chest (gauge)	235.3	238.2
first receiver (absolute)	103.6	108.8
F. L. P. receiver (absolute)	44.1	43.
A. L. P. receiver (absolute)	44.1	43.
Vacuum in condensers, inches of mercury	25.8	26.7
Mean effective pressures, main engines:		
high-pressure cylinder	111.6	112.3
intermediate-pressure cylinder	40.	43.2
forward low-pressure cylinder.	21.8	23.6
after low-pressure cylinder	22.45	22.3



CURVES REPRESENTING RESULTS OF STANDARDIZATION RUNS.

Mean pressure, in pounds per square inch on low-pressure piston, equivalent to aggregate M. E. P. on all pistons	51.87	54.
R. P. M. of main engines (mean)	151.36	150.2
average for both	150.78	
circulating pumps	185.7	188.2
blower engines (8) average	348	
Double strokes of main air pumps	20.5	24.
main feed pumps	28.1	30.8
auxiliary condenser pumps	0.	29.5
sanitary pump	16.9	
fire and bilge pumps	33.3	33.4
Air pressure, in inches of water, average.	1.63	
Speed of ship, in knots	22.13	
Slip of propellers, in percent of their own speed, based on mean pitch	22.84	23.67
Indicated horsepower, main engines:		
H. P. cylinder	3,810	3,805.9
I. P. cylinder	3,791	4,061.9
F. L. P. cylinder	2,785	2,992.3

A. L. P. cylinder	2,868	2,833.7
Total	13,254	13,693.8
Total, both main engines	26,947.8	
Indicated horsepower, auxiliaries:		
Main air pumps	10.7	12.4
Main circulating pump engines	73.2	76.
Main feed pumps (2)	67.2	77.
Auxiliary condenser pump	0.	3.2
Sanitary pump	1.5	
Fire and bilge pump	3.8	3.9
Blower engines (8)	122.4	
Dynamo engines	85.4	
Total all auxiliaries	536.7	
Total, all machinery in operation	27,484.5	
I. H. P. (total) per sq. ft. grate surface	19.8	
" " " heating surface	0.429	
Coal, kind and quality:	Pocahontas, hand picked, excellent	
pounds per hour	44,992	
pounds per sq. foot of G. S. per hour	32.4	
pounds per sq. foot of H. S. per hour	0.703	
pounds per I. H. P. for all machinery in operation	1.64	
pounds per I. H. P. for main engines, air circulating and feed pumps	1.65	
Cooling surface, square feet per I. H. P.	0.97	
Heating surface, square feet per I. H. P.	2.32	
Temperature, atmosphere, deg. F., average	53.8	
engine room, upper platform, average	80.1	
working platform, average	72.2	
fire rooms, above gratings, average	88.	
working level, average	98.	
injection water, average	47.9	
overboard delivery, average	100.6	
hotwell, average	67.7	
main feed, average	130.3	
smoke pipes, base, average	685.	

BUILDERS' TRIAL.

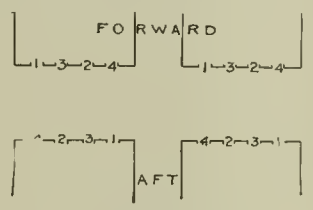
The *St. Louis* left the contractors' yard at 8 a.m. April 4th, and came to anchor outside of the Delaware breakwater at 5 p.m. On the 5th, after adjusting compasses, the ship was headed straight out to sea, making progressive increases of speed for periods of about twenty minutes each, until the maximum was reached and maintained for twenty-five minutes. Forced draft was not used until the last half hour of the run, revolutions up to 120 per minute being easily maintained under natural draft. The machinery, both main and auxiliary, worked very satisfactorily. This trial was made to break in the crew and limber up the machinery.

OFFICIAL TRIALS.

The *St. Louis* left Philadelphia the morning of May 8th for Boston. On the 9th, from 9 to 10.30 a.m., while steaming up the coast, the engines were run at full speed, all machinery running smoothly without heating. Anchored inside of Boston light ship at 9.45 p.m. Went into dry dock, Boston Navy Yard, at noon, May 10th. Left the dry dock at 1 p.m. on the 12th, and proceeded up the coast, coming to anchor at Rockland, Maine, at 8 a.m. the 13th. Before coming to anchor three runs were made over the measured course, to identify the range marks. May 16th the standardization trials were run. Fourteen single runs were made over the course, beginning at 6-52-10.1 and finishing at 9-54-52.5 a.m. The first five runs were made at full speed, the remaining nine at slower speeds, as shown by the table. A mean speed for the first five high-speed runs was 22.123 knots, and was obtained as follows: The five runs were divided into two groups, namely, runs 1, 2, 3 and runs 3, 4, 5. The sum of No. 1 run plus twice No. 2 run plus No. 3 run was divided by four to get the mean of the first group. A mean of the second group was found in the same manner. The means of these two groups were then added and divided by two to get the mean of the five runs, which was used as the high point of the speed curve. The speed curve showed that the *St. Louis* would have to make 149.6 revolutions per minute to make the contract speed of 22 knots. After the standardization runs the ship returned to Rockland and anchored inside the breakwater.

The four-hours' endurance trial was begun at 9.21 a.m. and finished at 1.21 p.m. the 17th. The average speed for the four hours was 22.13 knots, with an average of 150.78 revolutions per minute. The weather conditions were excellent during the trial. The main engines ran smoothly and without the use of water on any of the bearings or working parts. All auxiliaries worked well and at a very moderate speed.

The firing of the furnaces was controlled by electric bells rung by a man with a watch, stationed in No. 4 fireroom. The furnace doors were numbered as per sketch.



FIRING DIAGRAM.

The signal to work the fires was given at intervals of one and a half minutes, the cycle of operation being as follows:

1 bell, rake No. 1, fire No. 3;
2 bells, rake No. 2, fire No. 4;
3 bells, rake No. 3, fire No. 1;
4 bells, rake No. 4, fire No. 2.

There being four furnaces to a boiler, each furnace was fired every six minutes. By this arrangement a very uniform steam pressure was maintained. The fires were kept bright and even, and there was at all times an abundance of steam. The safety valves lifted repeatedly during the trial. The boilers were tight, and showed no signs of the severe demands of the full speed test, notwithstanding that the power developed was far in excess of that designed.

The amount of lubricating oil used during the 12 days' absence of the ship from Philadelphia, including the trials, was 1,982 gallons—less than 40 barrels. Loss of fresh water during the four hours' trial was 17.22 tons. No live steam was used in the receivers during the trial. The steam was cut-off in high-pressure cylinders at 85 percent of the stroke. There were 170 men in the engineering department, including 94 firemen and coal passers.

Value of Naval Architects. There is a general tendency to reduce shipbuilding more and more to a fine art; to appreciate more and more the value of technical training given naval architects, and of a through knowledge of the trade of the world. The movement in favor of a chair of naval architecture at Liverpool and another at Newcastle is gaining ground. Even with these and the one at Glasgow, Great Britain will be far behind Germany and the United States in facilities for technical training. The countries named were the first to realize the value of technical education, and they produced early a large number of students capable of becoming leaders in their different walks of life. In its lack of scientific training Great Britain lost ground in shipbuilding for nearly a century prior to 1860, and to maintain the supremacy of the sea she must see that a race of naval architects is trained to take over the profession as the present generation retires from the field we are occupying so creditably.—*Glasgow Herald.*

COLD STORAGE ON BOARD SHIP.

PART II.

BY SYDNEY F. WALKER, M. I. E. E.

METHODS OF COOLING THE COLD CHAMBERS.

We will now examine the method by which the cold is conveyed to the chambers. Having made a box, so to speak, into which heat is to a certain extent prevented from entering, how is the low temperature to be produced in the box, and how is the heat that does pass through the walls of the box to be carried away? For shipboard work the following methods are permissible: the use of brine, the direct use of carbonic acid where it is the refrigerating agent, and the use of cooled air. With brine and with carbonic acid directly employed, pipes are laid in the chamber to be cooled, usually in the form of a grid, sometimes on the side, sometimes overhead, sometimes, as mentioned above, a grid of pipes separates two bays, and sometimes the pipes are formed into a wall. The length and size of the pipes are calculated from the quantity of produce that is to be stored, and the leakage into the chamber that may be expected. With brine cooling, brine is kept in circulation in the pipes. The brine may consist of salt water—not sea water, but water in which common salt has been dissolved—but it more often consists of a solution of chloride of calcium.

It was mentioned above that dissolving a substance in water lowers the freezing point of the solution, and that is the reason why brine is used. One percent of common salt in water reduces

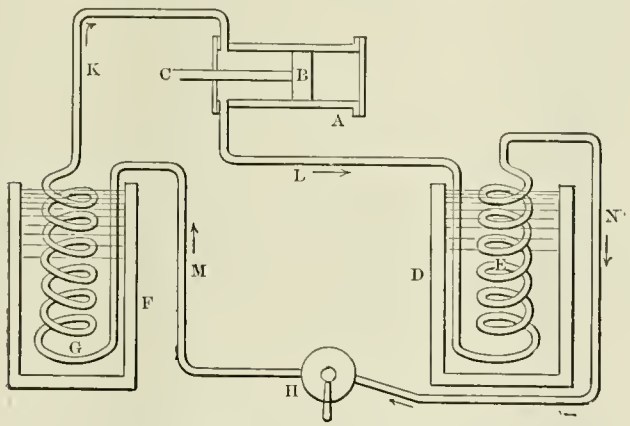


DIAGRAM SHOWING CIRCUIT OF REFRIGERANT.

A.—Compressor. *B. C.*—Piston and Rod. *D. E.*—Condenser and Coils. *F. G.*—Evaporator and Coils. *H.*—Expansion Valve. *K. L. M. N.*—Delivery Pipes.

the freezing point to 30.5 degrees F., 3 percent brings it to 27.8 degrees, 5 percent to 25.2 degrees, and so on. One percent of chloride of calcium lowers the freezing point to 31 degrees F., 5 percent to 27.5 degrees, 10 percent to 22 degrees, 15 percent to 15 degrees, 20 percent to 5 degrees, and 25 percent to —8 degrees. Common salt is not used now, except in special cases, for reasons that need not be mentioned to marine engineers. A 20-percent solution of calcium chloride is usually employed, or, if especially low temperatures are required, a 25-percent solution.

The use of a liquid that freezes at temperatures below that at which the produce is to be held is necessary. The brine itself is cooled by one of the processes that will be described, and it is caused to circulate continually from the tank in which it is cooled, through the pipes connecting it with (and forming) the grid in the cold chamber, and back to the tank again. In passing through the grid in the cold chamber it absorbs heat from the air in the chamber, which in its turn takes heat from the produce, and so on. Heat flows from bodies at higher temperatures to those at lower temperatures, and as the entering brine is at a lower temperature than the air in the room it is to cool, heat flows to it. The brine in the return pipe is, therefore, at a higher temperature than that in the supply pipe, and as the brine which passes through it, back to the evaporating tank where it is cooled, is at a higher temperature than its surroundings in the evaporating tank, heat again flows from it to the refrigerating agent. As explained in connection with the apparatus for "chilled" beef, the attendant knows by the difference between the temperature of the flow and that of the return brine pipes of each particular section of the chamber what work in the matter of cooling is going on, and this applies also to each chamber. It is not a difficult calculation to determine the quantity of brine that must pass through a particular cold chamber in a certain time, to keep the chamber at the required temperature or to reduce the produce to its keeping temperature—having given the number of heat units to be carried away in the same time, ascertained in the manner explained above.

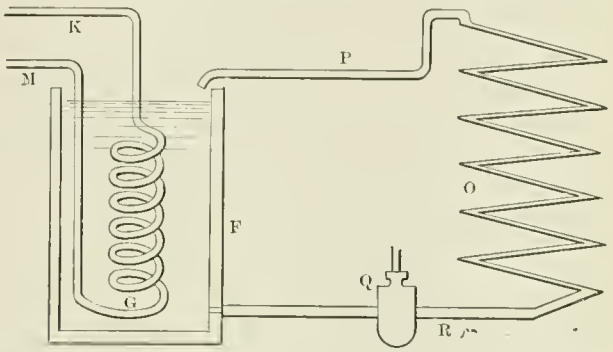


DIAGRAM SHOWING BRINE CIRCUIT.

F. G.—Evaporator and Coils. *K.*—Refrigerant Outlet. *M.*—Refrigerant Inlet. *O.*—Brine Grid in Cold Chamber. *P.*—Brine Discharge Pipe. *Q.*—Brine Pump. *R.*—Brine Pipe Leading to Grid

A 20-percent solution of calcium chloride has a specific gravity of 1.18, so that a gallon (Imperial) of the solution weighs 11.8 pounds. The specific heat of the solution is 0.834, therefore each gallon that passes through the pipes carries off 9.84 heat units for each degree F. that its temperature is raised. Brine is usually worked with an increase of temperature of from 6 to 8 degrees

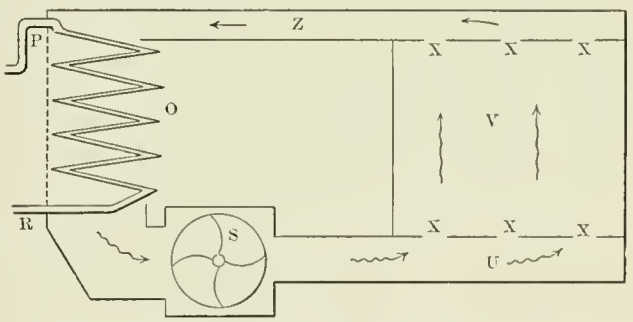


DIAGRAM SHOWING AIR CIRCUIT.

O.—Brine Grid in Cold Chamber. *P.*—Pipe from Evaporator Tank. *R.*—Pipe to Expansion Tank. *S.*—Fan. *U.*—Cold Air Duct. *V.*—Chamber to be Cooled. *X.X.*—Air Ports. *Z.*—Exhaust Air Duct.

F. between the entrance and outgoing ends of the grids, hence if we take an average rise of 4 degrees, since the temperature of the brine will be continually rising as it passes through the pipes, each gallon will carry off 39.36 heat units. The pipe used for brine cooling ranges from 1-inch bore to 2 inches. The external diameter of a 1-inch pipe is 1.3 inches, while that of a 2-inch pipe is 2.4 inches (about). The mean surface of pipe exposed to the heat will be, in the case of the 1-inch, 43.3 square inches per running foot of pipe, and that of the 2-inch pipe 83 square inches per running foot.

If we take Peclet again as a guide, we can calculate approximately the number of heat units that will pass through from the air into the brine in any given time. He gives 230 as the number of heat units per square foot of surface that will pass through

one inch thickness of iron, in one hour, with a difference of temperature of one degree F. The thickness of 1-inch bore iron pipe is approximately 1/8 inch, and of 2-inch pipe 1/7 inch, hence the rate of passage of heat through the walls of the pipe should be respectively 1,840 and 1,610 units per hour per square foot for every degree of rise in temperature of the brine, or again 928 units per running foot with 2-inch pipe, and 550 with 1-inch pipe. In practice the grid is made longer than would be apparently necessary, and more surface is exposed to the action of the heat, in order that the brine may flow at a lower velocity, and also because the results obtained in service do not usually come up to laboratory tests.

There is an important point in connection with this. Power, it will have been observed, is required for abstracting the heat and carrying it away. Where brine cooling is employed, power is required to keep the brine in circulation, and this power is in direct proportion to the extent of the wetted surface of the pipe, and to the square of the velocity at which the brine is flowing. Hence it will be seen that it would not be difficult to add appreciably to the power required by the plant as a whole by giving the brine a high velocity. Practice as usual has solved the question for itself, by the usual methods, and the following figures may be taken as the latest: A cubical space such as that taken, 12 feet on the side, if well insulated, requires, to be held at 32 degrees F., the temperature for "chilled" beef and some other substances, a length of about 432 feet of 1-inch pipe, and about half that length of 2-inch pipe, with roughly proportionate lengths of intermediate sizes. Small rooms require more pipe in proportion than large rooms. Thus with rooms under 1,000 cubic feet capacity 400 feet of 1-inch pipe and half that length of 2-inch pipe is given; while for cold chambers of over 10,000 cubic feet capacity 200 feet of 1-inch pipe and half that length of 2-inch is given, in each case per 1,000 cubic feet.

For lower temperatures, again, longer lengths of pipe are required, and approximately in the following proportions: for a temperature of 10 degrees F., double the lengths of pipe are required that are given for 32 degrees F., and for zero F. temperature about three times that given for 10 degrees. The velocity of the brine is usually kept at or below 3 feet per second. A high velocity has another serious drawback, unless large pipes are employed—all fluids flowing through pipes create friction, which generates heat, and consequently by raising the temperature of the brine lowers its ability to carry off heat from the room it is to cool. Brine coils are made in various lengths, according to the work they are to perform and the sizes of the pipes, from 100 feet with small pipes, for low temperatures, up to 1,000 feet with 2-inch pipes, and higher temperatures.

DIRECT EXPANSION.

By direct expansion is meant the direct action of the refrigerating agent, usually carbonic acid gas, on board ship, except where compressed air is employed in the chamber to be cooled. As will be explained, the refrigerant is caused to assume alternately the liquid and the gaseous state. A compressor and other apparatus are employed to reduce it to the liquid state, in which condition it is conveyed to the expansion coils, consisting of pipes very similar to those that have been described for the brine. The anhydrous liquid, on passing into the expansion coils, being suddenly released from the pressure under which it is held, is reformed into gas; but as a liquid can become a gas only by the addition of the latent heat of the gas, it abstracts this heat from surrounding objects, such as the brine with which the expansion coils are in contact, in the brine tank, or from the air of the chamber in which the coils are placed, where direct expansion is employed. The action, so far as the cooling of the chamber and the produce is concerned, is exactly the same as with brine cooling.

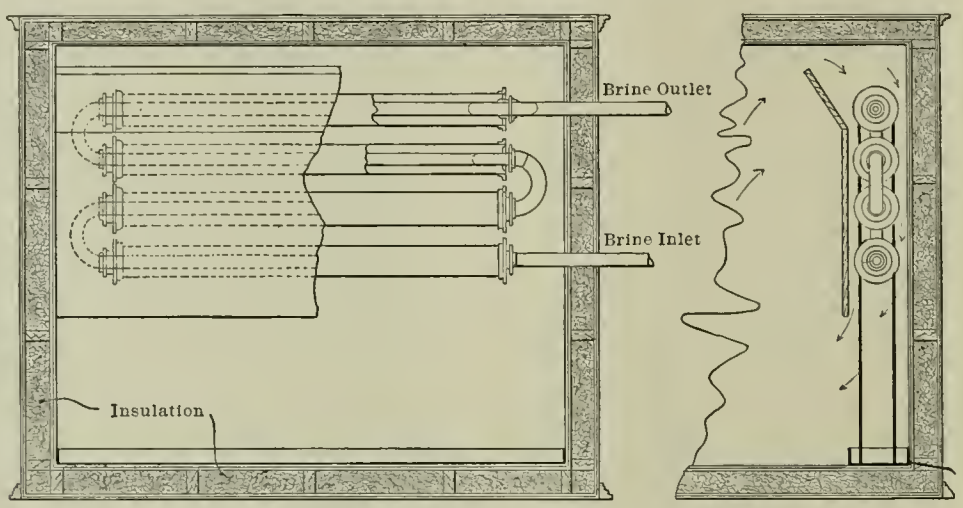
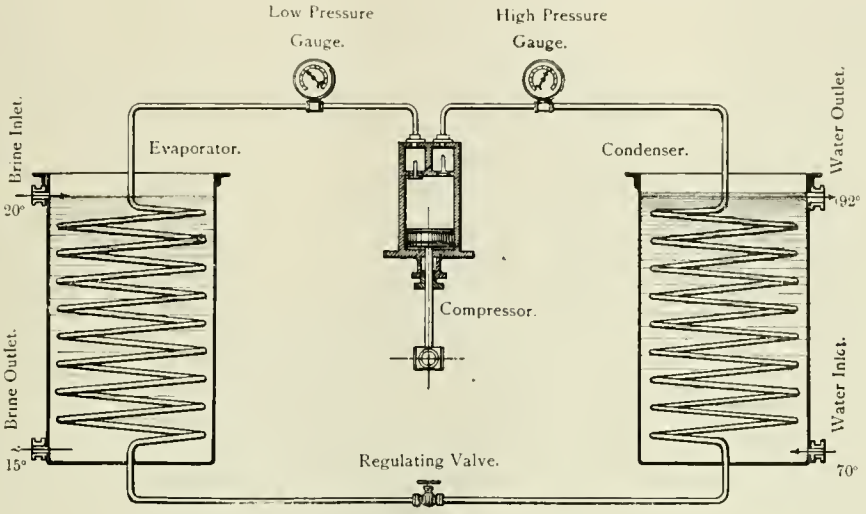


DIAGRAM SHOWING WEST ACCUMULATIVE SYSTEM OF COLD STORAGE.

There is a difference of temperature between the pipe containing the refrigerant and the air surrounding the pipe, because the refrigerant has been lowered in temperature, immediately on its entrance into the expansion coils, by the evaporation of a small portion of itself. Heat passes from the air of the chamber to the surface of the pipe, and thence through the pipe to the refrigerant, this heat enabling more of the liquid to evaporate, abstracting more of the heat from the air, and so on. Heat passes from the produce to the air surrounding it, so long as any difference of temperature exists between them, and hence the produce and the air of the chamber are kept at the temperature required, by the aid of the direct evaporation of the refrigerant, just as by the circulation of the brine. The refrigerant is maintained in continual circulation, just as the brine is; for the compressor, which performs also the duty of a pump, causes it to be continually passing from the condenser to the evaporator coils, thence to the compressor, and to the condenser again, as will be described.

The passage of the refrigerant into the evaporator coils is controlled by an expansion valve, which is practically a stop valve of particular construction. By its aid more or less of the liquid refrigerant is allowed to pass into the expansion coils. The length of the latter can be found by calculation and has also been determined by practice, though the calculation is somewhat different from that for the length of brine coils. Each pound of each kind of refrigerant absorbs a certain number of heat units, in passing from the liquid to the gaseous condition, the number of units absorbed varying with the temperature and the pressure.

Carbonic acid absorbs about 110 heat units per pound at the usual evaporator pressure, in temperate climates, while at higher pressures a smaller quantity is absorbed, 86 units at 650 pounds pressure, and 66 units at 800 pounds pressure. The temperatures corresponding to these pressures are 32, 50 and 68 degrees F. At lower temperatures the pressures are lower, 380 pounds at 14 degrees F., and 288 pounds at —4 degrees F.



KROESCHELL CYCLE OF OPERATION, SIMILAR TO HALL AND LINDE CYCLES.

At 32 degrees F., and the pressure given above, one pound of carbonic acid measures 0.167 cubic feet, or a cubic foot weighs approximately 6 pounds. It will be understood that *volumes* of gaseous substances that are pumped to and fro have to be dealt with, rather than *weights*. One cubic foot of carbonic acid will, therefore, absorb about 660 heat units in passing from the liquid to the gaseous condition at 32 degrees F. The gaseous carbonic acid formed from the liquid also carries off a certain quantity of heat, just as the brine does, but it is bad engineering to allow much of this to be done. The specific heat of carbonic acid gas is 0.2167, so that while one cubic foot of the liquid, in expanding to a gas, abstracts 660 heat units, the same quantity of the gas, in passing through the remaining pipes of the expansion coils, will absorb only 1.3 units, for every degree of difference in temperature between it and the atmosphere of the room.

With direct expansion the lengths of the pipes will be much less than with brine. Ammonia and sulphurous acid are employed as refrigerants, but there is the great objection to direct expansion with ammonia, that the escape of a small quantity of the gas, in the cold chamber, may seriously affect the produce. Sulphurous acid does not labor under that objection, for the substance itself is used as a disinfectant, but it has not so far been much employed on board ship. The calculation for the quantity of the other refrigerants, and the size and length of the pipes, is practically the same, using different constants, as with carbonic acid. Ammonia absorbs 555.5 units per pound at 0 degrees F., while sulphurous acid absorbs 171.2 per pound. It will be understood that the gas which is formed is pumped through the grid of pipes, and thence to the compressor, to be reconverted into liquid, so that the friction of the gas in the pipes has to be taken into account, in the same way as the friction of the brine, and it follows the same laws, depending upon the surface of the pipe rubbed over by the gas, and upon the velocity at which the gas travels. A low velocity is of some value here.

(TO BE CONTINUED)

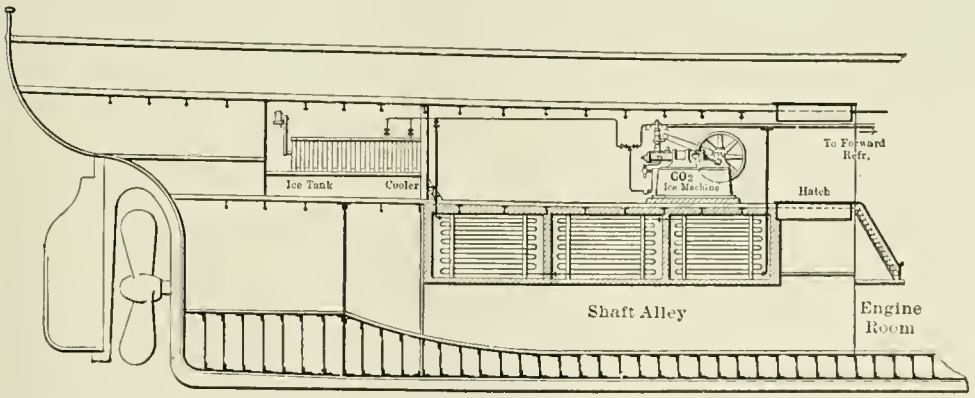


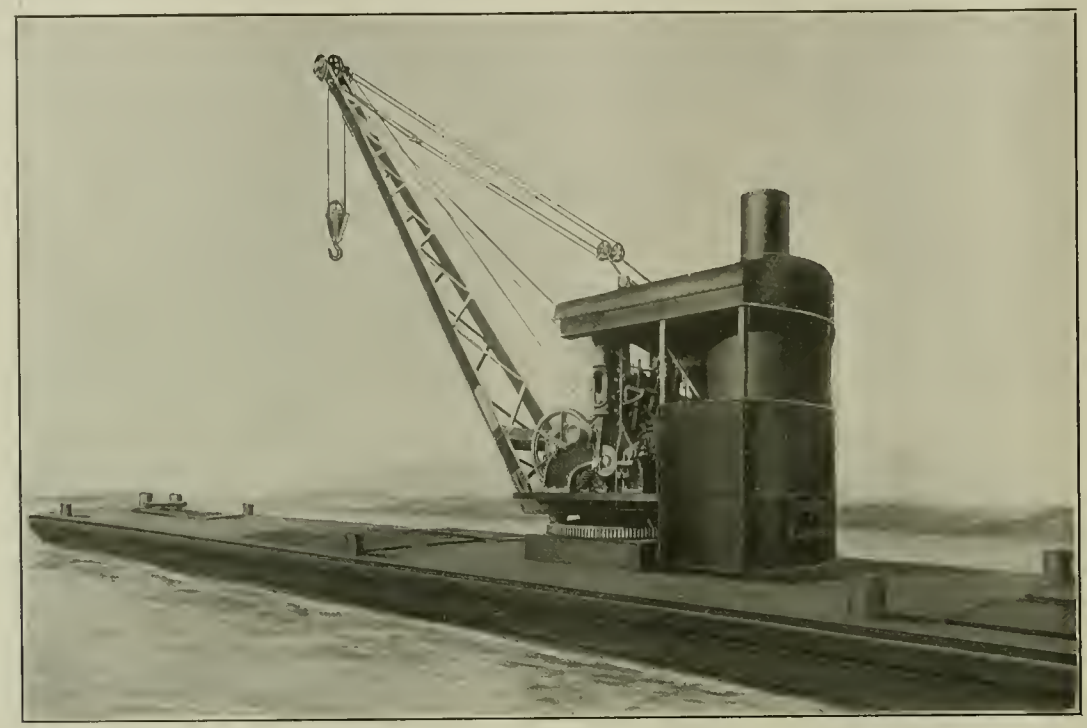
DIAGRAM OF KROESCHELL MARINE PLANT ON MORGAN LINE STEAMSHIP LOUISIANA.

Common Sense Versus Brute Force.

Several years ago I was a passenger on a single screw transatlantic liner operating under one of the foreign flags, and an accident occurred in the engine room which necessitated bringing the vessel to a stop and replacing one of the crank pins. None of the ordinary devices used was successful in even starting the pin from its position, and heroic measures were adopted by bringing down from the deck a heavy carronade, which had been kept there for saluting purposes. This was swung by tackle in such a manner that it could deliver powerful blows against the

end of the crank pin. The successive concussions jarred the entire vessel, but did not produce the desired result.

At this juncture an American gentlemen, of engineering training, offered his services to the captain, stating that he would agree to remove the pin without injury to the machinery or ship, if given a free hand and absolute command in the engine room for a couple of hours. His advances were repulsed until finally, nothing having been accomplished by the engine room staff, they were accepted in desperation.

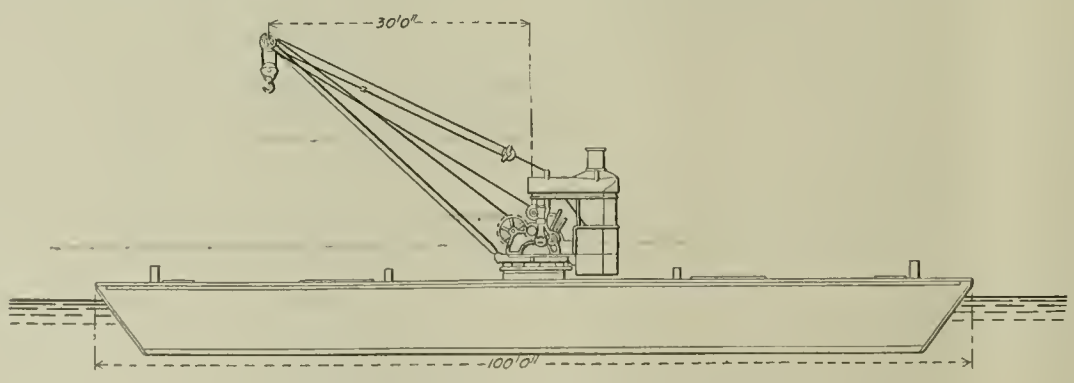


GENERAL VIEW OF DERRICK CRANE MOUNTED ON SCOW.

His method was very simple, consisting merely in building a large fire under and around the crank pin, the exposed parts of the vessel having been previously protected by iron plates. By the time the crank pin had begun to glow with a red heat the expansion had become sufficient to enable the pin to be driven out by a single tap from the carronade. G. M. P.

feet, at which radius the maximum height of lift from the bottom of the hook is 21 feet. The maximum load of 10 tons can be raised at a speed of 50 feet per minute, while a light load can be operated at 125 feet per minute. Complete rotation of the crane with full load can be made in twenty seconds, while without load an entire circumference can be traveled in ten seconds.

It should, of course, be noted that the lifting capacity of the crane at different radii directly abeam is somewhat dependent upon the stability of the scow. In order to increase the stability, and in view of the fact that the scow is narrow, the boiler is swung considerably to the rear of the pivoting point, and a counterweight is placed beneath it to partially balance the weight of the load being lifted. Operation is entirely by means of steam, with the usual drums for wire ropes, the steam being furnished



SIDE ELEVATION OF FLOATING SCOW DERRICK CRANE.

Floating Scow Derrick Crane.

Our illustrations show a new floating crane built by The Wellman-Seaver-Morgan Company, Cleveland, Ohio, for Japan. The crane is very similar to the regular locomotive crane equipment of this company, and is mounted upon the center of a scow having a length over all of 100 feet and a width of 20 feet. The boom has a length of 36 feet, and a radius of action of 30 by a vertical tubular boiler and operating a vertical double-cylinder high-pressure engine fitted with a reversing gear. Two drums are used, one for adjusting the radius of action, and the other for the operation of hoisting and lowering the loads. In addition to this, there is the necessary mechanism for rotation about its axis. The operator's platform is in a cab between the boiler and the engine and drums, and in full view of the work

THE NEW STEEL PADDLE WHEEL EXCURSION STEAMER SOUTH SHORE.

The *South Shore*, which has been built of mild steel throughout, has the following dimensions:

Length over all	205 feet 6 inches
Length between perpendiculars	200 feet 0 inches
Breadth over guards	56 feet 0 inches
Breadth molded	32 feet 6 inches
Depth molded	12 feet 0 inches
Extreme depth to top of dome	33 feet 0 inches

The vessel has been constructed with four decks: lower, main, saloon and hurricane, the three last named being carried out to the extreme width of the vessel, affording great deck area for saloon accommodations and promenading.

On the lower deck forward sleeping quarters are arranged for the crew and firemen, also storerooms and steering engine compartment. Aft a spacious officer's dining room has been fitted up, with crew's mess room and kitchen, and at the extreme after end, cabins for officers and stewards. Leading from this deck to the main deck there are three large stairways.

The main deck forward is bulkheaded off to form freight space, with large gangways opening into same. Abaft these and abreast of the boiler casing, wing houses are built, containing men's toilet and lavatory arrangements, on the starboard side, and on the port side crew's wash room, lamp room, storeroom and check room, while amidships a large lunch room has been built, with hinged shutters opening on three sides. In the midship portion of the vessel on this deck a neatly panelled wood casing has been arranged around the engine hatch and the deck itself carried with an easy slope over the paddle shaft, which is a considerable improvement on the older method of forming a step, and thereby causing a dangerous stumbling block in the passage ways. After wing houses adjoining paddle box have been arranged for the first mate and chief engineer.

Outside of the saloon enclosure proper, the after main deck saloon has been arranged in three compartments, all of them well lighted by large sliding windows. Forward, the quarter deck compartment is handsomely fitted up with mahogany dado and panelled sides finished in white and gold with artistic frieze. At each side there are spacious mahogany stairways leading to the saloon deck above. Immediately aft of these spaces the ladies' cabin is located, fitted with olive colored plush sofas and finished in a similar manner to the quarter deck inclosure. At the extreme end of the house, ladies' lavatories, etc., have been arranged. There is ample walking space around this house on the outside, with deck lights arranged underneath the seats for lighting officers' quarters on the lower deck.

The saloon deck extends for about seven-eighths of the entire length of the vessel, and has a panelled deck house for about one-half this length, lighted by large sliding windows, and upholstered, with cane bottomed chairs arranged around the sides in groups, and in the center line. This saloon will provide those passengers with shelter from wind and sun who do not care to avail themselves of the promenade outside. On each side, at the forward end of paddle boxes on this deck, the purser's room and directors' room are located.

The hurricane deck is built on top of the saloon deck house, for one-half its length, and has a large well-lighted dome supplying light and air to the saloon below. Arranged around the after end are slat seats, and at the forward end there is a commodious house fitted up as captain's, pilot's, mate's and quartermaster's cabins, with pilot house at the extreme end of these. Ten life boats are stowed on this deck, with facilities for handling them rapidly in case of emergency.

THE NEW NANTASKET BEACH STEAMER SOUTH SHORE.

The propelling machinery consists of one set of compound diagonal surface condensing engines, supplied with steam by two large boilers, the installation aggregating 1,200 horsepower, which will give the vessel a speed of about 15 miles per hour.

The *South Shore* is lighted throughout by electricity, and in addition a powerful searchlight has been mounted on top of the pilot house, and a number of large deck lights arranged in the open for illuminating the promenades at night.

Altogether the vessel is a notable addition to the already large fleet of the Nantasket Beach Steamboat Company. With her great accommodations, modern methods of construction, and the ample conveniences provided for the comfort of passengers the steamer should prove one of the best and most popular excursion vessels on the Atlantic coast.

Everything that forethought could suggest with a view to insuring the safety of the passengers has been incorporated on this vessel, comprising life boat, life raft and life belt capacity to take the entire complement of 2,300 people. Numerous hydrants, with their attendant hose lengths, have been arranged in easily accessible locations, and, most important of all, there is a more minute sub-division of the steel hull than has been hitherto attempted in this class of vessel, so that, in the event of a collision, the vessel's buoyancy will be interfered with to

a minimum. It is well within the bounds of moderation to assert that this vessel in equipment, design and construction is probably in advance over any vessel at present plying in these waters.

She was built by the Fore River Shipbuilding Company, of Quincy, Mass.

MOTOR BOATS.

PART XIV,

BY DR. WILLIAM F. DURAND.

PROPELLER DESIGN.

The problem of propeller design forms naturally an integral part of the general problem of speed and power; for no matter how accurately the power provided may be suited to the speed desired, the latter will fail of realization unless the boat is provided with a propeller suited to the efficient absorption and transformation of such power into the work of boat propulsion. In fact all formulæ and methods for determining the power suited to a desired speed are based on the assumption of a reasonably efficient propeller, and without such propeller all such formulæ and methods as those discussed in the preceding chapter are meaningless.

The general problem of propulsion is, if possible, more complex than that of ship resistance, and in these pages we shall not undertake any detailed consideration of this problem. It will be sufficient to note that the propulsion of a boat requires the development of a propulsive thrust sufficient to balance and overcome the resistance opposed by the water to the motion of the boat. This propulsive thrust may be viewed in two ways: (1) As the reaction resulting from the sternward acceleration of a column of water which is laid hold of by the propeller in a condition of rest and given a motion sternward or opposite to that in which it is desired to propel the boat. (2) As the resultant of the resistance which the blades of the propeller meet with in passing through the water, such resultant due to the oblique form of the blades having a forward component and constituting the propulsive thrust. The two methods are of course fundamentally the same, and represent different view points for the same phenomenon.

In no case is any complete rational theory of the screw propeller possible in the present state of our knowledge, and for practical purposes, therefore, methods must be devised in which the chief characteristics of the propeller are connected by means of empirical factors or constants with the conditions to be fulfilled.

Including a reasonably adequate analysis, the performance of a propeller may be reduced satisfactorily to its dependence on the following features:

(1) Diameter.
(2) Pitch.
(3) Revolutions.
(4) Slip at which operated.
(5) Blade area.

Of these items, numbers (1) and (2) determine between them the pitch ratio, while (2), (3) and (4) determine the speed.

Before proceeding with the discussion of actual formulæ for screw propeller design, reference must be made to the double aspect in which the term *slip* may present itself for consideration.

If we suppose a propeller of pitch p and revolutions N working in undisturbed water at a speed of advance v feet per minute, then the actual slip is $(pN - v)$ and the slip percent is $(pN - v) \div pN$. This is the so-called true slip, and is reckoned relative to the water close about the propeller and in which it is working. Now, when a boat is propelled through the water, the action of the boat on the water is to produce, as is well known, a following current or wake, most noticeable close about the stern. It is therefore in this wake or current of water which is moving forward relative to the surrounding body of still water that the propeller must work, while it is relative to the surrounding body of still water itself that speed is judged. It thus follows that the speed of the boat and the slip of the propeller are not determined from the same standard, and that the speed of the boat relative to the wake is less than that relative to surrounding still water, while the slip is correspondingly greater. The slip relative to the wake, however, must be the true slip, since it is in the wake water that the propeller is working. The decreased slip relative to the surrounding body of still water calls therefore for separate recognition and is known as the *apparent* slip.

The formula for apparent slip is thus the same as that given above for the true slip, but in this case v must be understood as referring to the speed of the boat through the still water. In any given case the difference between the two values of the actual slip is, of course, the speed of the wake or following current. In percentage of the product pN, the difference may vary widely between little or nothing for short, narrow fine lined boats with the torpedo boat or modern stern, to 20 per cent or more for large full boats with the older form of stern. Its value is furthermore distinctly less with twin than with single screws.

The performance of a propeller, so far as efficiency is concerned, and as an actual instrument of propulsion, must be judged, of course, relative to the water in which it is working; while so far as speed is concerned, it must be judged relative to the surrounding body of still water. In any method of propeller design providing for a recognition in detail of all the various factors which exercise a controlling influence, this double aspect of the slip must be recognized, with an estimate of the difference between the two values in any given case.

It should be understood at this point that the method of propeller design here proposed is not intended to provide in detail for the recognition of all of the factors and influences above noted, and in particular for a detailed recognition of the influence due to the wake. It is intended rather as a convenient and relatively simple method for the guidance of those who are not experts in this field, but who may wish to derive the dimensions of a propeller with some assurance of a reasonably satisfactory result.

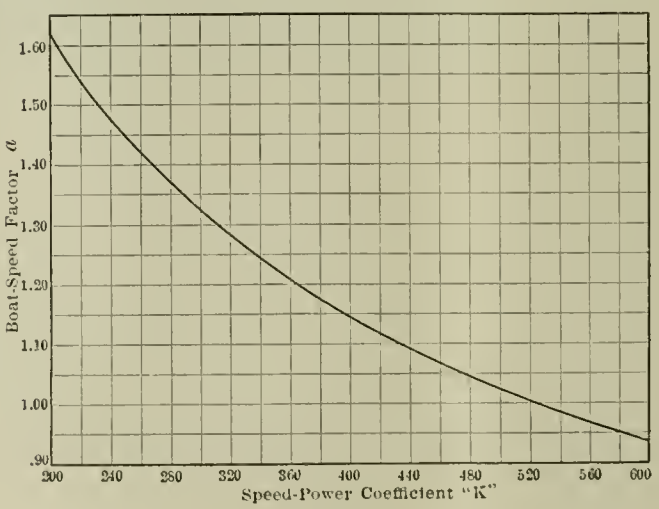


FIG. 58.

Turning now to the development of actual formulæ and methods, we first note that in the formula for power as discussed in the preceding chapter, the relation between power and speed is made to depend on the cube of the latter. It is furthermore a fact that in all formulæ for propeller performance, no matter how disguised, the power absorbed by the propeller is also held to vary with the cube of the speed. It would

therefore seem natural to expect that, by an appropriate combination of these two formulæ, we should be able to eliminate the item of power, and thus relate the dimensions of the propeller directly to those of the boat and to the other general conditions of the problem. Such a direct relation of the propeller to the boat is not unreasonable when we remember that in effect it is the resistance of the propeller which provides the propulsive thrust for overcoming the resistance of the boat. There is thus a balance between the resistance of the boat and the fore and aft component of the resistance experienced by the blades of the propeller, and under such circumstances it seems reasonable to assume that the size of the propeller may be related directly to the size of the boat, the details of the relationship being made to include the speed and such other special items of the case as the data in hand will permit.

A further reason for the convenience of a formula of this character is found in the fact that frequently the size, weight or displacement of the boat is known independently of the power or speed, and it may be desired to determine the size of propeller independent of the special question of power The problem thus becomes one of fitting to a given boat a propeller such that whatever the power, it will be economically absorbed for propulsive purposes, and such speed realized as may properly be expected under the conditions.

We will now proceed with a statement of the formula proposed, and its illustration by numerous examples.

Let W = weight or displacement of boat in pounds, or in case of twin or triple screws, weight divided by 2.83 or 5.2 respectively.
v = speed in miles per hour.
d = diameter of propeller in inches.
p = pitch of propeller in inches.
N = revolutions per minute.
a = boat speed factor, derived from Fig. 58.
b = slip factor, derived from Fig. 59.
c = pitch ratio factor, derived from Fig. 60.
c = area factor, derived from Fig. 61.
s = apparent slip.

Then we have:

$$d = a\ b\ c\ c\ \sqrt[3]{W} \quad \ldots\ldots (1)$$

$$N = \frac{1056\, v}{p\ (1-s)} \quad \ldots\ldots (2)$$

$$s = \frac{pN - 1056 v}{pN} \quad \ldots\ldots (3)$$

$$p = \frac{1056\, v}{N\ (1-s)} \quad \ldots\ldots (4)$$

The fundamental equation (1) signifies simply that for single screw boats the diameter of the propeller in inches is equal to the cube root of the displacement or total weight in pounds multiplied by the combination factor $a\ b\ c\ c$, the values for which are to be derived from the special circumstances of the case. For multiple screws the operation is the same except that for W a certain fraction of the total weight is to be taken as noted above. The fundamental equation will thus serve to determine the diameter, and from this the pitch, revolutions and surface area will result directly from the various special assumptions which have been made in connection with the factors b, c, c.

On the other hand, if the revolutions, diameter or pitch is fixed in advance, some one of the factors b, c or c will be left to be determined by the fundamental equation, and the possibility of a satisfactory solution with the assumed values will be indicated by the resulting value of such factor. These various points will be made clear by means of illustrative problems to follow.

We must first, however, discuss briefly the character of the factors a, b, c, c.

The boat-speed factor is intended to take account of the dimensions and form of the boat, especially in relation to the expected speed. In Fig. 58, values of this factor are plotted on an axis of values of the Admiralty displacement or speed-power coefficient K, as used in the formula for powering. The values of a are in fact equal to $\sqrt{524 \div K}$. Reference may therefore be made to the discussion regarding suitable values of K, previously given in connection with the speed-power problem, and the same value of K used in Fig. 58 will then serve to indicate a suitable value of a. For reasons of numerical convenience the standard value of $a = 1$ is taken to correspond to $K = 524$. Remembering then that the usual values of K range from 200

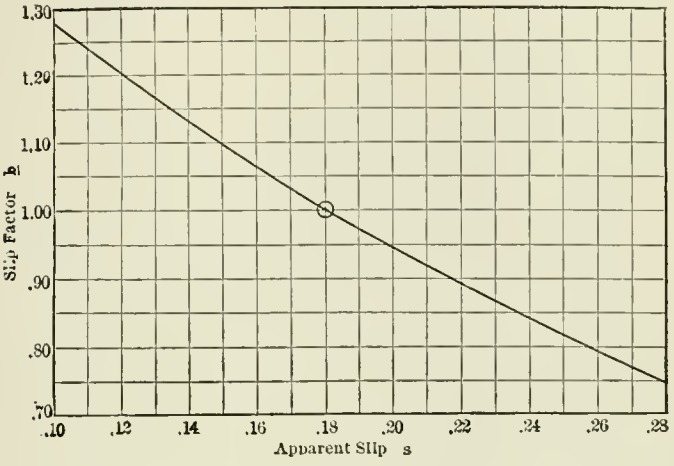


FIG. 59.

or 250 to 500 or 550 it follows from Fig. 58 that the corresponding values of a will range from close about 1 upward to about 1.5.

The slip factor b is intended to provide for the increasing thrust which is obtained with increasing slip, and the consequent permissible reduction in the diameter of the propeller. The slip is one of the conditions which must usually be assumed in the solution of the problem, and the value first assumed must often be modified in order to finally reach an adjustment of the result complying with the main conditions of the problem. It will be noted that the slip used in Fig. 59 is the *apparent* and not the

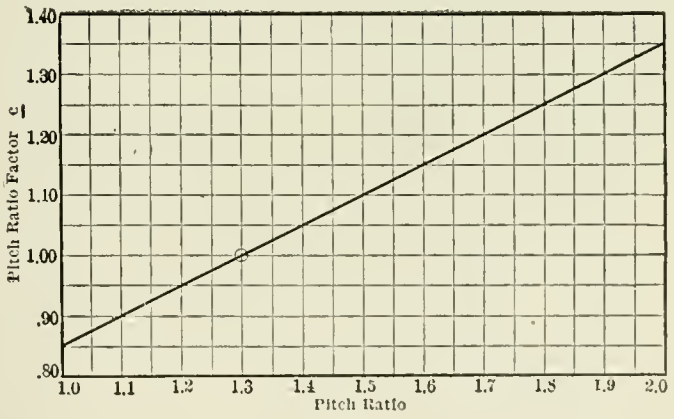


FIG. 60.

true slip. Reference may also be here made to the discussion of the difference between these two terms, which has been presented at an earlier point in connection with the speed-power problem. A strictly rational analysis of propeller action would require an estimate of the wake influence, and thus of the difference between the two values of the slip. For purposes of simplicity, however, we have assumed a standard value of the wake of ten percent of the speed of the ship, and have arranged the values in Fig. 59 on this assumption. For the purposes for which this manual is intended, the error involved in this assumption will usually be unimportant.

The pitch-ratio factor c is intended to take account of the fact that, other things being equal, the higher the pitch ratio the

lower the thrust, and *vice versa:* with corresponding effect on the necessary diameter of the propeller. The selection of a pitch-ratio is often a matter of arbitrary choice, and the value first selected may frequently require re-adjustment, either to bring the revolutions within a suitable limit, or to make possible a satisfactory result on a specified diameter. These points will appear more clearly in connection with the illustrative problems given at a later point.

The surface-area factor c is intended to provide for the slowly increasing thrust with increase of area. The standard form of blade assumed is supposed to be elliptical or oval in contour, and the standard surface area is taken as .40 of the disk area of the propeller. For such area the value of the factor is 1, while for other values of the area ratio the values are as given by the diagram of Fig. 61. Detailed investigations on the influence due to area show that it depends on both pitch ratio and slip, but for simplicity the indications of the diagram are intended to apply more especially to average values of the slip, and to values of the pitch ratio close about 1.3.

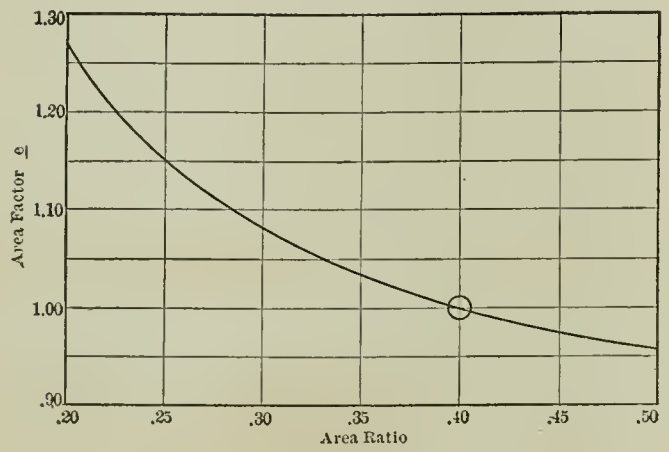


FIG. 61.

With regard to area-ratio, its usual value for propellers of two, three and four blades may be indicated as follows:

Let d = diameter of propeller.

A = total blade area.

$$\text{Then area-ratio} = A \div \left(\frac{\pi d^2}{4}\right)$$

For two blades, area-ratio is usually found between .20 and .25;
For three blades, area-ratio is usually found between .30 and .40;
For four blades, area-ratio is usually found between .35 and .50.

ILLUSTRATIVE PROBLEMS.

We shall here take, in general, the same cases used for illustration in the speed-power problems of the preceding chapter.

(1) Given $L = 36$ feet,
$W = 12.000$ pounds,
speed = 9 miles per hour,
One propeller, four blades.
Assume $K = 300$.
Then $a = 1.32$.
Take trial slip = .18 and pitch ratio = 1.3,
Then $b = 1$,
$c = 1$.
Assume standard area ratio.
Then $e = 1$.
We then have:

$$d = 1.32 \sqrt[3]{12,000} = 1.32 \times 22.89 = 30.21 \text{ inches.}$$
$$p = 1.3 \times 30.21 = 30.27 \text{ inches.}$$
$$N = \frac{1056 \times 9}{39.27 \times .82} = 295$$

This propeller is readily seen to have an excessively large diameter and pitch, with correspondingly low revolutions. The trial assumptions should therefore be so modified as to reduce the dimensions and increase the revolutions.

To show the influence of a single change, let us take pitch ratio = 1.2. Then $c = .95$ and we have:

$$d = 1.32 \times .95 \times 22.89 = 28.7.$$
$$p = 1.2 \times 28.7 = 34.44.$$
$$N = \frac{1056 \times 9}{34.44 \times .82} = 336$$

Again, let pitch ratio = 1.1. Then $c = .90$ and we have:

$$d = 1.32 \times .9 \times 22.89 = 27.19.$$
$$p = 1.1 \times 27.19 = 29.91.$$
$$N = \frac{1056 \times 9}{29.91 \times .82} = 387$$

Again, with pitch ratio = 1.1, let slip = .20, and we have $b = .95$, $c = .9$. This gives:

$$d = 1.32 \times .95 \times .9 \times 22.89 = 25.83.$$
$$p = 1.1 \times 25.83 = 28.41$$
$$N = \frac{1056 \times 9}{28.41 \times .80} = 418$$

Any one of these several propellers might be expected to develop the desired speed on approximately the indicated revolutions, and in general to effectively take its part in the attainment of any speed of which the conditions will permit. Still further decrease in dimensions and increase in revolutions can be made if desired. These successive steps are given to show the method of gradually approaching a combination result which shall satisfy the general requirements regarding these various features. In the remaining problems the values will be so chosen as to give immediately a more satisfactory series of values.

(2) Given $L = 33$ feet.
$W = 3600$ pounds.
Speed = 15 miles per hour.
One propeller, four blades.
Assume $K = 300$.
slip = .18.
pitch ratio = 1.4.
Then $a = 1.32$, $b = 1.00$, $c = 1.05$ and take $e = 1.00$.
Then we have:

$$d = 1.32 \times 1.05 \times \sqrt[3]{3600} = 21.25 \text{ inches.}$$
$$p = 1.4 \times 21.25 = 29.75 \text{ inches.}$$
$$N = \frac{1,056 \times 15}{29.75 \times .82} = 649.$$
$$A = .40 \times 353.6 = 141 \text{ square inches.}$$

Such a propeller might then be reasonably expected to develop a speed of 15 miles per hour on about 650 revolutions per minute, or any proportional speed on approximately corresponding revolutions, and in general to efficiently do its part in the attainment of any speed of which the controlling conditions will permit.

(3) Given $L = 24$ feet.
$W = 4800$ pounds.
Speed = 7 miles per hour.
One propeller, four blades.
Assume $K = 250$.
slip = .20.
pitch ratio = 1.0.
We then have:

$$a = 1.45$$
$$b = .95$$
$$c = .85$$
$$e = 1.00$$
$$\sqrt[3]{4800} = 16.87$$

Hence $d = 1.45 \times .95 \times .85 \times 16.87 = 19.75$ or say 20 inches
$p = 1.0 \times 20 = 20$ inches

$$N = \frac{1056 \times 7}{20 \times .80} = 462$$

(4) Same as problem (3), but driven at speed of 8.5 miles, and with value K reduced to 200. Then $a = 1.62$ and with the other assumptions as before we should have:

$$d = 1.62 \times .95 \times .85 \times 16.87 = 22.07 \text{ or say } 22 \text{ inches}$$
$$p = 1.0 \times 22 = 22 \text{ inches}$$
$$N = \frac{1056 \times 8.5}{22 \times .80} = 510$$

(5) Given $L = 56$ feet
$W = 12{,}000$ pounds
Speed $= 25$ miles per hour
One propeller, four blades
Take K $= 350$
Suppose N fixed at 1000.

Then we proceed as follows:

Assume slip $= .18$ and pitch ratio $= 1.2$, leaving e to be determined. Then:

$$p = \frac{1056 \times 25}{1000 \times .82} = 32.2 \text{ inches}$$
$$d = 32.2 \div 1.2 = 26.83, \text{ or, say, } 27 \text{ inches.}$$

Then to test the possibility of such a propeller we substitute in formula (1) and find the resulting value of e thus:

$$27 = 1.22 \times .95\ e \times \sqrt[3]{12{,}000} = 26.53\ e$$
$$\text{or } e = 27 \div 26.53 = 1.018$$

This value of e is only slightly larger than 1.0, and denotes therefore an area ratio slightly larger than .40, or otherwise, with area ratio .40, the indications are that with the same propeller the slip would slightly increase and the revolutions rise slightly above 1000. In either case the propeller should substantially realize the conditions imposed. In case a pitch ratio greater than 1.2, such as 1.3 or 1.5, had been assumed, the resulting value of d would have been too small, and the value of e would have resulted much less than 1.00. Any such value as .8 or .9 for e thus indicates an impossible propeller, or an impossibility of fulfilling the conditions on the diameter indicated. On the other hand, should the value of e result much larger than 1, it shows that the diameter may be reduced, and still provide for the realization of the conditions imposed. A value of e slightly larger than 1.00 denotes, of course, an area ratio less than .40, in accordance with the indications of Fig. 61. In any case, where the resulting value of e does not agree with the indications of Fig. 61, changes must be made in the pitch ratio assumed, and thus by successive trials a final satisfactory combination result may be realized.

(6) We will assume the same data as in (5), but with twin screws. Then we have $12{,}000 \div 2.83 = 4240$, and $\sqrt[3]{4240} = 16.19$. Now assume a pitch ratio of 1.45, and slip $= .18$, as in (5). Then we have:

$$a = 1.22$$
$$b = 1.00$$
$$c = 1.075$$
$$d = 32.2 \div 1.45 = 22.2 \text{ inches.}$$

From formula (1):

$$22.2 = 1.22 \times 1.075\ e \times 16.19 = 21.23\ e$$
$$\text{or } e = 22.2 \div 21.23 = 1.046.$$

This value of e indicates an area ratio of .36 or .37, a value suitable for three blades, which are very commonly used for twin screw propellers.

(7) Given $L = 40$
$W = 5000$
Speed $= 28$ miles
Take $K = 500$
slip $= .18$
pitch ratio $= 1.6$
area ratio $= .40$.

Then we have:

$$d = 1.025 \times 1.15 \times 17.1 = 20.15, \text{ or say, } 20 \text{ inches}$$
$$p = 1.6 \times 20 = 32 \text{ inches}$$
$$N = \frac{1056 \times 28}{32 \times .82} = 1127$$

(8) Given $L = 41$
$W = 3300$
Speed $= 26$ miles
Take $K = 500$
slip $= .16$
pitch ratio $= 1.9$
area ratio $= .40$

Then we have:

$$d = 1.025 \times 1.06 \times 1.30 \times 14.89 = 21 \text{ inches}$$
$$p = 21 \times 1.9 = 39.9, \text{ say, } 40 \text{ inches}$$
$$N = \frac{1056 \times 26}{40 \times .84} = 817$$

In example (7) the values are so selected as to give a relatively small propeller with high revolutions; while in (8) the values are selected so as to give a larger diameter (though the boat is smaller) and with a marked reduction in revolutions. These two examples illustrate typical cases with extreme speeds, and indicate the wide range of flexibility of which the designer may take advantage in adapting his designs to the various special conditions of the problem.

GAS POWER FOR MARINE WORK.

BY GODFREY M. S. TAIT.

There is one great drawback to the continued use of fair sized gas engines, and that is the cost of the gasoline fuel, and it is with a view to offering a remedy for this drawback that the writer has investigated the gas producer as a fuel generator for this class of work.

It is an accepted fact that producer gas operated gas engines comprise the very cheapest method of power generation, and when in combination with this advantage we find that we can operate a plant of this description, by means of recent improvements, without the use of any fresh water whatever, and that the weight of the fuel (coal) does not exceed that of an amount of gasoline capable of doing the same work, the whole proposition appeals to us strongly.

Builders both here and abroad are now devoting their energies to working out a practical design with this type of power, and to a large extent their efforts have been crowned with success.

One of the problems which presented itself to the European builders when they came to redesign the gas producer for marine work consisted in the fact that a considerable quantity of fresh water had to be carried for use in the "evaporator," from which steam is drawn to be utilized as a means of preventing clinkering, and enriching the gas in the producer. This drawback bade fair to prove a serious one, but has now been overcome in this country by the patenting of a process of producer gas generation in which the use of steam or water vapor has been entirely eliminated, the place of the steam being taken by the exhaust gases from the engine, which are found to have a sufficient cooling effect, chemically, to thoroughly retard clinkering in the producer, while at the same time causing the generation of a gas absolutely free from hydrogen. The use of this process was found in practice not only to accomplish the results above mentioned, but in addition was found to generate gas of such a constant composition that analyses taken at frequent intervals during a 24-hour run, recently made by the writer, showed a variation of less than five percent in heating value.

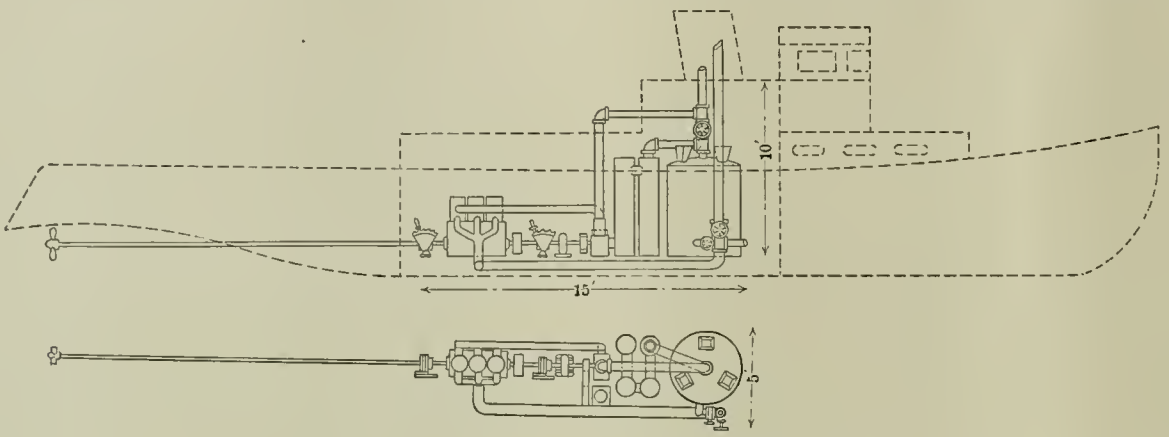
With a producer operating under these conditions, practically all danger from unreliable service is eliminated, while such occurrences as back-firing, pre-ignitions, etc., are entirely eliminated by the constant quality of the gas.

A marine power plant designed by the writer for installation on a 55-foot pleasure craft embodies in its design the improvements above mentioned.

The plant, which is shown in illustration herewith, and which is of 50 horsepower capacity, consists of a producer of special design, having its gas outlet in the center, and connected to four small cooling towers connected up in series, through which a spray of salt water is continually passing. From these cooling

towers the gas passes to a tar separator or fan, which, in addition to throwing off by centrifugal force the tarry particles, also removes the moisture, so that the gas, which is piped direct from the separator to the engine, is sufficiently dried to enable the engine to operate steadily.

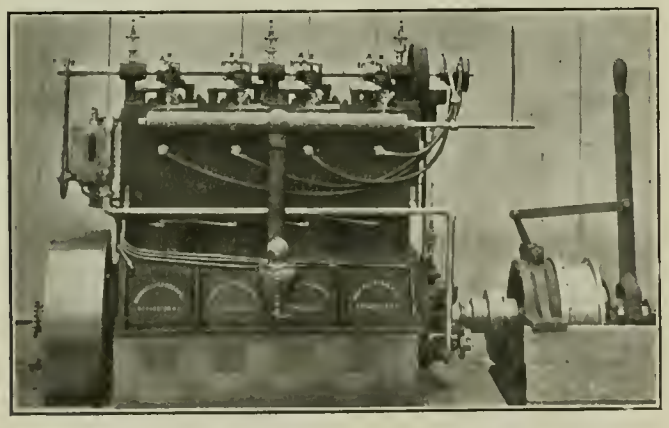
The engine shown in connection with this plant is built by the Brownell-Trebert Company, and was selected on account of its valve design, which admits of ready alterations so as to enable the engine to operate under 200 pounds compression, which is required with this type of gas.



OUTLINE DESIGN OF VESSEL TO BE PROPELLED BY PRODUCER GAS PLANT.

While it is not essential that engines with the valves opening directly into the cylinder head should be used with this system, it is found very much easier to make the equipments on this type of engine, while the efficiency obtained is considerably higher, due to the reduction in thermal losses from jacket water, as with this design practically all the compression space is utilized to exert a direct downward thrust to the piston head.

In this equipment it will be noted that in order that the engine might be enabled to operate in a horizontal position the propeller shaft terminates in a well (as can be seen in the cut illustrating the side elevation of the boat), of such design that when the boat is in motion the water will entirely fill this well and thereby cover the propeller blades. This arrangement was originally designed for boats operating on the Nile, where shallow draft was a necessity, but where screw propellers were preferred to side paddles, and the ingenious arrangement of using a well above the water line, which would be maintained full of water by the action of the propeller when in motion, was found to be eminently satisfactory, besides doing away with the pitch of the propeller shaft.



MOTOR FOR USE WITH PRODUCER GAS OUTFIT.

The producer, as well as the engine, is situated forward of the cabin, and the top of the former comes about flush with the deck line; the producer room being provided with hatches which are adapted to raise up when it is necessary to poke the fire or work around the top of the producer. The latter is equipped with a revolving grate of special design, which has a shearing effect upon the clinkers, and by means of which the fuel bed can be steadily lowered as the combustion takes place, the ashes falling into the ash pit, whence they can be removed once in eight or ten hours.

While this producer is designed for operation on anthracite coal, bituminous fuel may also be used when necessary, without interfering with the general operation, of the plant, the only change necessary in running being that constant poking is required with this latter type of fuel, due to its caking tendency.

In addition to the equipment mentioned, there is also an auxiliary 3-horsepower gasoline engine used for the purpose of running the air compressor for starting the engine, and also for blowing up the producer after it has been banked for any length of time. The lay shaft from this outfit is so arranged that when the main engine is in operation both the air compressor and blower may be operated direct, allowing the gasoline engine to come to a state of rest.

On the main shaft of the engine are located the tar separator and driving fan, and also the centrifugal pump which supplies water to the scrubber and the cylinder jackets. The engine is supplied with the usual form of reversing gear.

The total weight of this plant, including engine, producer, scrubber, auxiliary engine, etc., will not exceed 5 tons, and the space occupied is such as to leave ample room on the craft for other purposes. This boat is designed to carry one-half ton of coal in addition to what is in the producer, this being sufficient to operate the engine at full speed for ten hours, but should it be desired, additional stowage for coal could easily be arranged.

The labor required for this plant would be the services of one man to run the producer and engine, the same man being enabled to steer the boat most of the time, as the attention required by the producer is of an intermittent character.

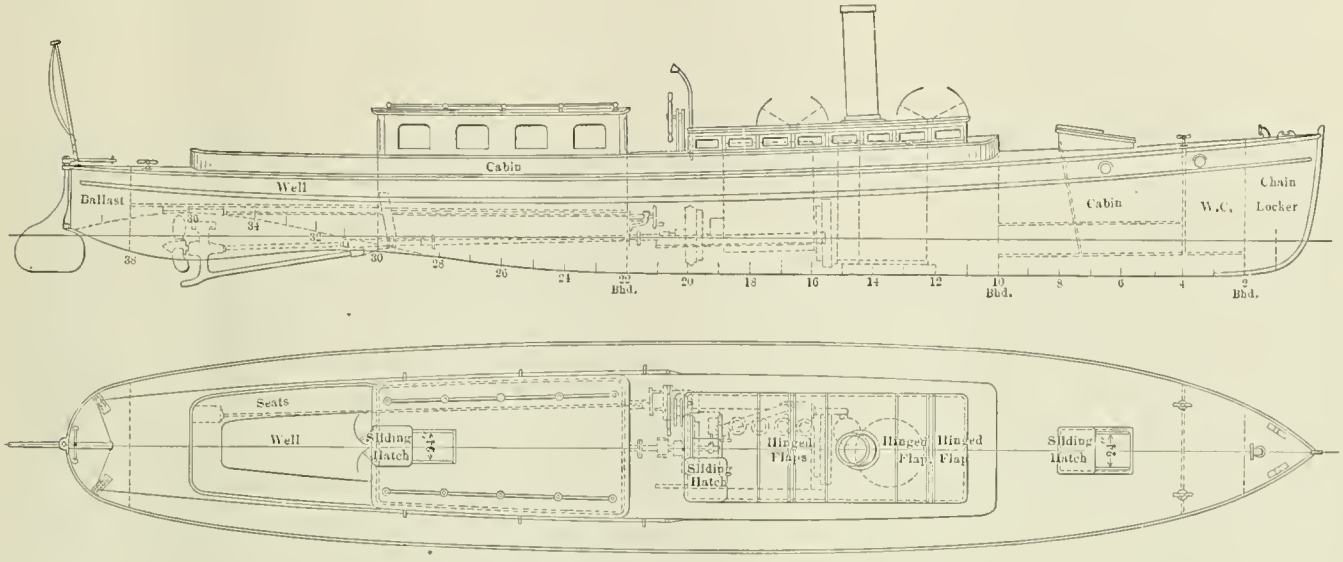
A plant similar to the foregoing, but designed for stationary purposes, was recently tested by the writer in a 24-hour run at a slight overload capacity, and was found to consume 1⅛ pounds of coal per brake horsepower per hour, the horsepower being measured by means of a water cooled prony brake. This plant operated without any shut-downs during this entire period, even when the fire was cleaned thoroughly, which occurred once in eight hours, and at no time was there any trouble from back-firing, pre-ignitions, etc.

In designing or purchasing a gas-producer-gas-engine operated craft the following desirable items as regards the power plant should be carefully borne in mind:

Compactness of design, minimum weight, ease of attendance, capacity to operate at full load for long periods, low first cost.

adaptability to operate on various sizes and grades of fuel, economy of operation, use of little if any fresh water.

If these points are carefully looked after there is now no reason why a gas-producer-gas-engine plant should not fill, with entire satisfaction, all the requirements of power propulsion for small craft at least, and in the course of a few years it is not unreasonable to expect to see some large ships also using this type of equipment.



THE SUCTION PRODUCER GAS VESSEL DALMUIR, PROFILE AND DECK PLAN.

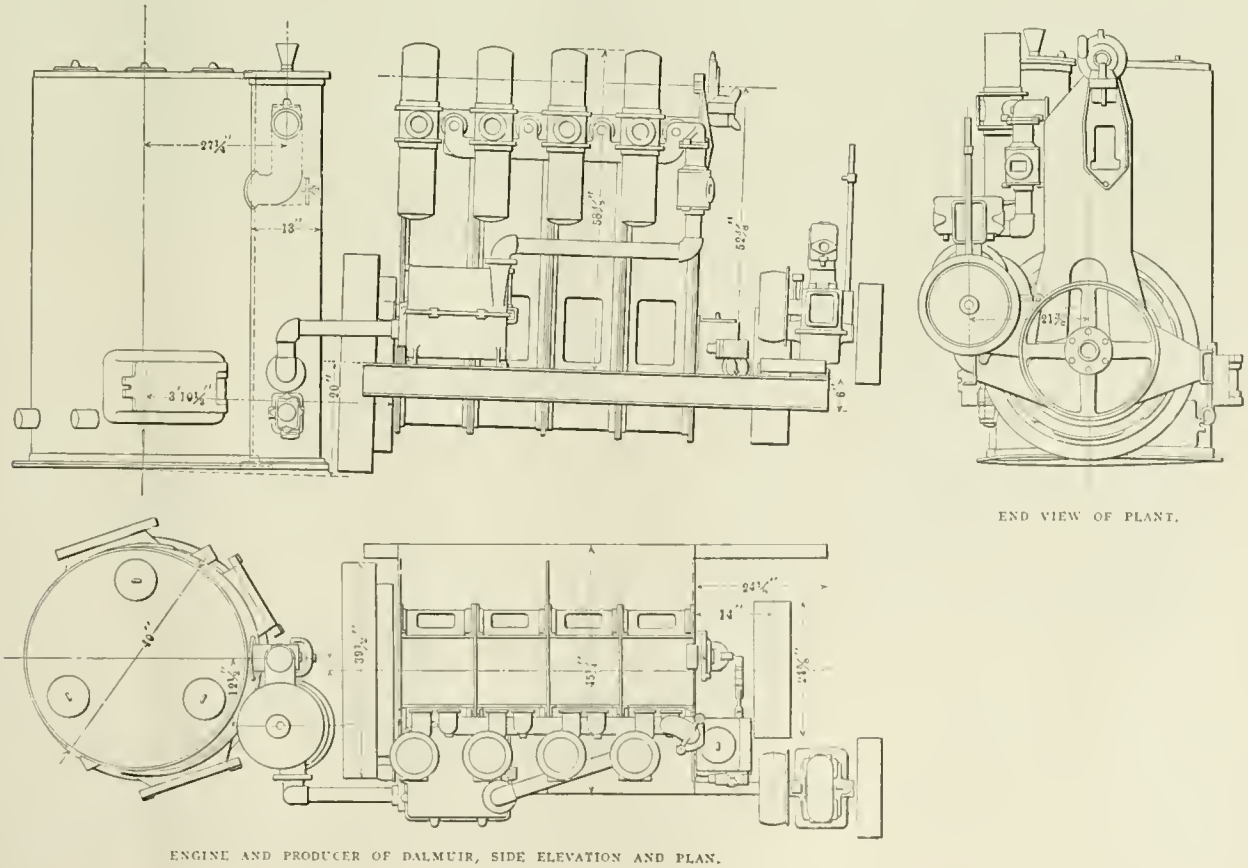
A Suction Gas Producer Vessel.

Messrs. William Beardmore & Co., Limited, Dalmuir, Clyde, who are jointly interested with Messrs. Thornycroft in working the Capitaine gas production system, have brought out the launch *Dalmuir*, which is the first vessel built in Scotland propelled by self-produced gas. We reproduce drawings illustrating this vessel and her engines and gas plant. The *Dalmuir* is 60 feet in length by 10 feet beam and 2 feet 6 inches deep. The reversing is done by means of a reversing propeller.

The vessel is fitted with the Thornycroft marine gas plant (Capitaine system), which consists of a suction gas producer in which the gas is generated, and an internal combustion engine working on the usual Otto cycle.

Either coke or anthracite coal may be burnt in the producer, and the gas is generated from a mixture of air and steam drawn through the incandescent fuel by the partial vacuum created by the outstroke of the piston in the engine.

The whole producer plant working at a pressure below that



END VIEW OF PLANT.

ENGINE AND PRODUCER OF DALMUIR, SIDE ELEVATION AND PLAN.

of the atmosphere, there is no chance of leakage of gas. Gas is produced only as it is needed by the engine, and in quantities to suit the varying loads, so that there is no waste while the engine stands idle. As no gas holder is necessary, there is no danger of explosion. A small floor space is ample.

The heat efficiency of this plant compares favorably with that of the very best compound condensing steam engine; being 23 percent, as compared with only 11 percent for the steam engine. That is to say, the gas plant consumes less than one-half the fuel which would be used in a steam boiler and engine of the same power.

A fair average consumption for different qualities of coal is 1 pound of fuel per brake horsepower per hour. If good anthracite be used, this figure may be slightly reduced. If the fuel be coke the consumption will be about 1¼ pounds.

The engine of the *Dalmuir* is one of the four-cylinder type, 60 horsepower, 240 to 360 revolutions per minute. The plant weighs 9,950 pounds and the propeller weighs 870 pounds. The dimensions of the plant are: 8 feet 3 inches by 3 feet 9 inches by 6 feet high. The drawings display the whole design of the vessel.

This gas engine launch is peculiarly interesting because it is a practical demonstration in miniature of a larger operation which Messrs. Beardmore have on hand, that may serve to revolutionize marine locomotion. They are just completing for a cargo vessel a single acting gas engine 20 by 24 inches. This engine has five cylinders, each section complete in itself, and so arranged that one, two, three, four or all sets may be operated. The crank is solid built, and there is reversing gear. This engine is to develop from 500 to 600 horsepower, and is to be fitted on board of a "steamer" that has been run for some years with ordinary reciprocating engines, so that a complete comparison may be made with previous records. The gas suction plant for this engine is of the same type as that on the *Dalmuir*, and is fitted to consume any quality of bituminous coal (not necessarily anthracite, which is dear in Great Britain), automatically fed. The vessel to be fitted with this engine will be at work in the course of the early summer, and she will be the first commercial vessel in this country propelled by internally produced gas.

Benjamin Taylor.

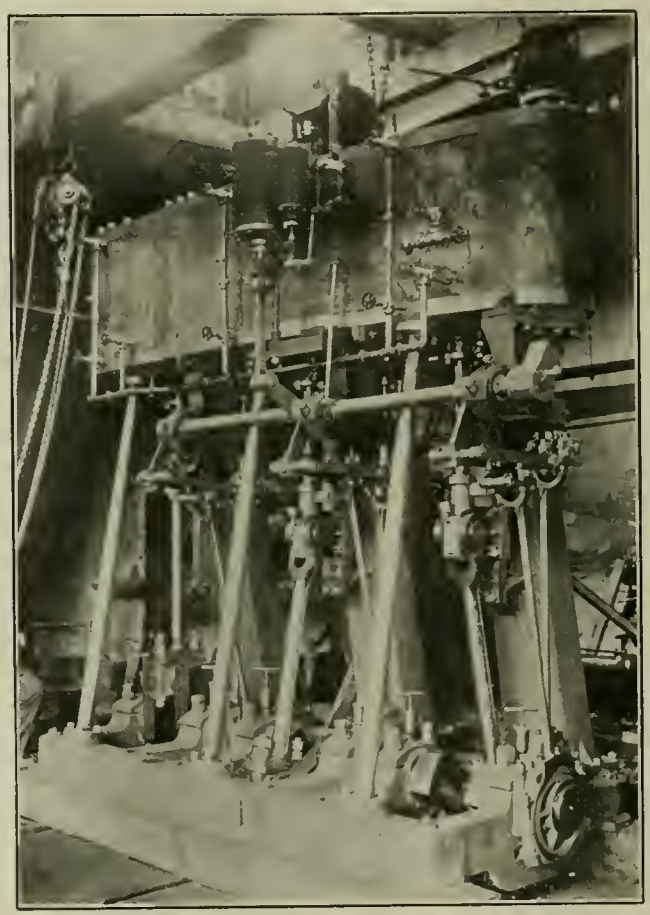
THE NEW PASSENGER STEAMER MAYWOOD.

A 600-HORSEPOWER TRIPLE EXPANSION MARINE ENGINE.

This engine was built by the Marine Iron Works, of Chicago, for the steamer *Maywood*, of the Escanaba and Gladstone Transportation Company.

The high and intermediate cylinders have ring fitted balanced piston valves, and the low-pressure double ported slide valves. Each cylinder and its valve chest are cast separate of semi-steel. Cylinders are well lagged with magnesia and jacketed. The pistons are of the dished type and made of cast steel. Piston rods are of steel, turned, ground and polished; crossheads of steel fitted with bronze boxes.

The cylinders are supported at the back by three hollow cast iron columns, to which are fitted hollow cast iron "bar" guides for the crossheads, the front framing consisting of three forged and turned steel columns. The forged connecting rods are forked at their upper ends and fitted with tapered, shouldered



600-HORSEPOWER ENGINE OF MAYWOOD.

and case-hardened crosshead pins; crank-ends are fitted with bronze boxes.

Each valve stem guide is cast in one piece with the stuffing box and rocker-shaft bearing.

The valve gear is of the Stephenson type, fitted with double bar links; reversing by steam cylinder connected direct to rocker-shaft arm, with independent adjustable cutoff to each valve. Eccentric rods have "T" heads at eccentric end, being forked at the top to span the link, and are fitted with bronze bearings.

The engine illustrated is of the following dimensions:

High-pressure, 14 inches diameter.

Intermediate, 22 inches diameter.

Low-pressure, 36 inches diameter.

Stroke, 24 inches.

The crank shaft is slotted out from a solid steel forging, the cranks being set at an angle of 120 degrees, the dimensions of crank-shaft being proportioned to the steam pressure and service.

The bed-plate is cast in one piece, having six pedestal bearings, each being fitted with bronze boxes lined with white metal.

The most approved "takeup" attachments are fitted to valve stem guides, link blocks, crosshead and crank brasses, etc.

The cylinders and valves are lubricated by sight feed oil pump operated by trip and rod connection to engine. Multiple box oilers with outside drop supply the crosshead guides, crosshead and wristpins; crank-shaft bearings are served by extra large compression grease cups; other parts, such as eccentric straps, etc., are fitted with oil and grease cups.

All the moving parts are closely counter-balanced, as demonstrated by the absence of vibration when the engine is driven at various speeds.

The *Maywood* has a length over all of 142 feet, a length on the keel of 130 feet, a beam of 25 feet and a depth of 10 feet 6 inches. Her gross tonnage is 398 and net tonnage 309. She has state room accommodations for fifty passengers, and excursion capacity for 450. In the hold forward and on the forward deck is a small space for cargo stowage. The dining room is on the main deck aft, above which, on the cabin deck, is a large covered promenade space. The vessel was built by the Manitowoc (Wis.) Dry Dock Company.

A Modern Dry Dock in Greece.

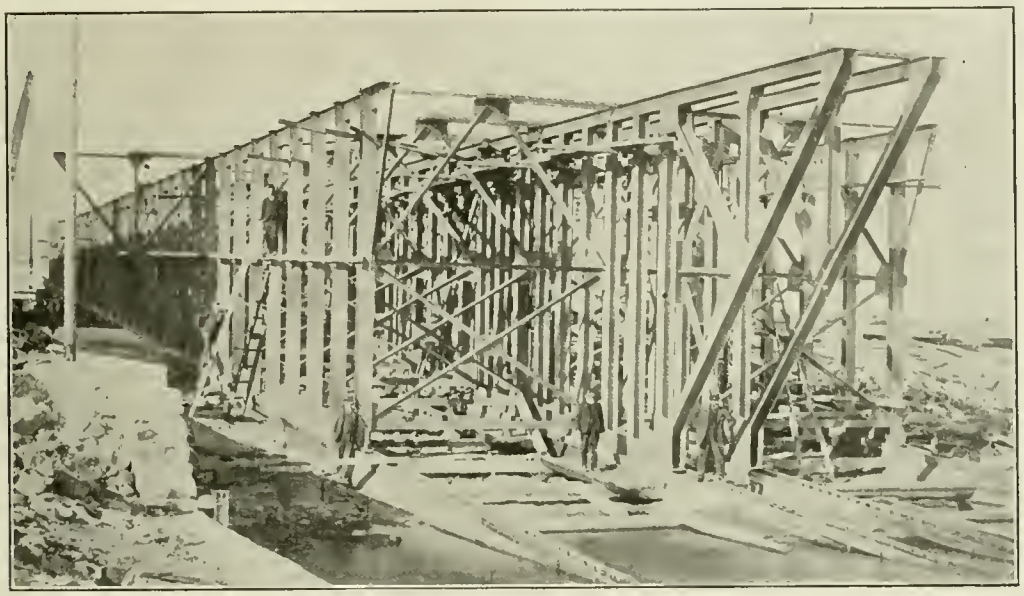
We illustrate a construction view of the aft built-up portion of a Crandall type of railway dry dock, constructed at Piraeus, Greece, for the Ateliers et Chantiers Helleniques "Basilades."

This dock has a capacity for docking a vessel of 4,000 tons dead weight. It is constructed of steel for the under body (as partly shown in illustration) with heavy timber cross beams resting upon the columns, and is decked over completely, with the exception of a space under the keel-blocks of 4 feet in width, purposely left open to facilitate repairs to ships' keels. A docking platform extends nearly the length of the dock on each side, from which are operated, by galvanized chains and geared winches attached to the uprights supporting the platforms, thirty-eight releasing bilge-blocks. The dock rests upon four tracks, which in turn are supported on concrete foundations, and is operated by electric power through a train of gears and six special long link chains attached to the dock by a patent equalizing gear, which absolutely equalizes the pull on each chain. The time required to haul, completely up, a vessel of 4000 tons, after it has been centered, ranges from 30 to 35 minutes. Quicker time can be made on smaller loads by using the fast gear. The roominess of the deck, the free access of light and air about the ship's bottom and the ease with which material may be placed at any desired point where it is most required, on account of there being no sides, greatly add to the efficiency of repairing vessels.

The following dimensions may be of interest:

Capacity—dead weight	4000 tons
Length on keel-blocks	336 feet
" " deck	356 "
Width over cross-beams	68 "
" between docking platforms	62 "
Depth of water over aft keel-blocks—dock down	20 "
Number of tracks	4
Grade of tracks	1:12
Distance of keel-block centers	4 "
" " bilge-block centers	12 "
Time of hauling full loads	35 minutes

This dry dock has recently been built by the H. I. Crandall & Son Co., East Boston, Mass.



STEEL FRAMEWORK OF RAILWAY DRY DOCK AT PIRAEUS, GREECE.

MARINE TURBINES IN SERVICE.

BY ROBERT S. RILEY.

With most engineers, not directly associated with turbines, the idea prevails that once a turbine is set up and running that is about all there is to it—that is, it has no individuality such as a reciprocating engine has, for everyone knows that a reciprocating engine has numerous personalities peculiar to itself. Some engines give trouble with the valve gear, others in the guides; another may have a pet crank pin that requires special attention, and so on to a legion of more or less important details, which every engineer has to study for each engine of which he takes charge.

It is true that the running part of a turbine consists simply of a revolving rotor. But there are other moving parts. In fact, with the refinement of clearances due to this method of using steam, almost every part of the entire turbine has to be considered a moving part, with a motion of its own. Contraction and expansion measure the extent of this movement, and any change of temperature supplies the necessary motive power. It will be seen, therefore, that this opens up a world of personalities in a turbine, which may be fully as complex as the vagaries of a quadruple expansion reciprocating engine. Every engineer knows that the behavior of an engine will vary with the speed, sometimes valve-gear and piston rods giving more trouble at low speed than at high. These peculiarities of a

reciprocating engine have been the subject of careful study, and long experience has shown how to provide for them. Besides this, the big high speed engines have been through such a process of evolution that each change or addition has not been very radical.

However, in the case of the turbine, designers have been forced at once into competition with reciprocating engines that have been the product of years of study to get them to their present size and efficiency. Naturally this results in some crudities, which experience and study may eliminate. To a certain extent, therefore, all turbines built are experimental as yet, but each gets nearer the future standard, and adds its quota to the general fund of information. Not that a turbine built today may become obsolete a few years hence; the general principles are established and will not change, but many details will. It is not probable, for instance, that old turbines will be displaced as old automobiles have been, for the latter are more or less of an undeveloped commodity, and their use gives rise to more notions each day; whereas the mission of the turbine is pretty clearly defined. It is to take the place of high-speed reciprocating engines, and do the work that they have done so completely for years.

There are now quite a number of sea-going turbine engineers, practically all of whom are in charge of Parsons turbines, as this is the only type as yet in general use on board ship. Talking over troubles and peculiarities with these men brings out the fact that there is a good deal more to be looked after than is generally supposed. For one thing the speeds are high and lubrication correspondingly more important. The two main bearings of each turbine are kept floating in oil under pressure. This is very essential, for if ever the metals should come into intimate contact without a film of oil interposed, the friction would soon be fatal. This has occured in one turbine job, with the result that the metal promptly melted, the alignment was thrown out, the blades of the rotor fouled those of the stator, and hundreds of them were stripped. This happened on the American coast, and an expert blader had to be sent from England to fit new blades.

This forced lubrication is therefore an added responsibility for the engineer, as it involves another complete system. The larger ships have this in duplicate, so great is its importance. But perhaps the greatest additional care required in lubrication come in the shaft alley. The forced lubrication takes care of the turbine bearings proper, but thus far has not been extended to the spring bearings. These bearings are generally a source of considerable anxiety. Water has to be used freely, and even then the temperatures are excessive.

It is a good thing that the line shafts can be made so much lighter and still transmit the same power as a slower speeded shaft. This off-sets, to some extent, the tendency of a shaft to heat, due to its own weight and rigidity in resisting motions of the ship.

One bearing, however, may be excepted from the general tendency to givem ore trouble than the reciprocating engine's, and that is the thrust. Here is an ideal condition, where the thrust of the propeller on the water is directly opposed by the thrust of the steam on the forward sides of the blades of the rotor. Conversely, when going astern, the pull of the propeller is opposed by the forward pressure of the steam on the go-astern blades.

The auxiliary machinery for circulating and air pumps is much larger than would be required with a corresponding set of reciprocating engines. This is due to the great importance of high vacuum in the economy of the turbine. The addition of intensifiers, or of dry air pumps, further complicates the engine room equipment. The intensifier is practically another small condenser for a steam siphon which increases the vacuum in the main condenser. This additional vacuum is held in the main condenser by means of a differential water seal in the pipe connecting the two condensers. The dry air pumps are likely to be finer pieces of machinery than ordinary air pumps. Their valves are positively driven, instead of automatically.

We hear a good deal of the successful working of the turbine, and very little of its troubles. Nevertheless the latter occur. Sometimes the most trivial change in normal conditions causes an abnormal contraction or expansion, and the blades foul. For instance, one steamer had been in successful operation for over two years; the low pressure turbines had been running "dead slow" in a fog for one hour, longer than they had ever been before, so that they were running on cold vapor, and were quite cold from end to end. An order came for "full speed astern". The rush of hot steam through the astern blades of the rotor shell caused a sudden expansion, and blades that had cleared for two years, fouled and wrecked themselves, putting one turbine out of commission instantly, though nothing appeared on the outside to indicate anything wrong.

Another case occured on a liner which had run successfully for some months. The propellers were changed from four to three bladed, with consequent speeding up of the turbines above the designed speed. In setting a governor, it is supposed that one low-pressure turbine ran a few revolutions above the maximum allowed. The construction of the rotor drum was such that the butt straps holding together the plates of which it was composed, formed a powerful moment under the action of centrifugal force. The circumference of the shell was distorted, and the blades touched and were stripped.

As an off-set to the liability of injury to the blades it may be said that turbines run practically as well with a large number removed. Thus, in the two cases just cited, the covers were lifted at the first opportunity and the stripped blades removed from casing and rotor. It was impractical to re-blade them at the time, so the casings were replaced with the blades missing. No serious difference was noticed, and each ship did its duty until an opportunity arrived for re-blading.

An interesting case of this kind happened recently in a stationary plant. A large number of blades were stripped: the casing and rotor were lifted immediately, and the stripped blades removed. The turbine was started again and ran continuously, each working day, without further trouble. Each night the cover and rotor were lifted and a ring or two of blades inserted until they were all complete again. It is doubtful if any job of similar magnitude could be done in instalments thus on a reciprocating engine.

Most men in charge of turbines claim that it is a "chief engineer's job"; that is, the final responsibility rests on one man, and he cannot delegate it to the same extent that can be done with a reciprocating engine. There is no chance to "take leads" to bring up and show the chief how things are running. If he has reason to question the clearance of blades anywhere, he must spend anxious minutes with his ear on the casing, while the turbine is speeded up cautiously, listening intently for the faintest sound of interference. Adjustments can be made to allow for the wearing down of the main bearings, but this is very seldom required with perfect lubrication. Each case of adjustment calls for renewed careful listening and cautious speeding up, for once a blade touches strongly enough to bend it, they all go down like nine pins, and a "ten strike" is easily made.

An obstruction accidently left in the casing would mean ruin to the blades, if it were swept into them by the rush of steam. Even a small piece of waste, or an overall button would be sufficient to start a "ten strike". As these casings at the condenser end are sometimes large caverns into which men go for observation, it will be seen that the man responsible will be pretty careful not to let anything drop or be left behind by mistake.

Taking it all together, however, the turbine men are agreed that they would rather take care of a turbine than almost any reciprocating engine. There are fewer details to worry about, and those that do give trouble are apt to be strictly "up to" the designer, rather than to the operating engineer.

Probably the method of fastening the blades is the most critical point at present. Great improvements have been made however, and it is likely that the problem will soon be satisfactorily solved. It is all expert work, and the average operating engineer is not likely to have much to do with it. Experience will probably develop the art to such an extent that stripped blades will be very rare. The clearance spaces are already considered of less moment than formerly, and this relieves much of the danger of fouling. Improved facilities for finishing the ends of the blades or shroud rings will leave them less liable to fouling. There is also quite an art in the design of casings so that they will not change form too radically upon the application of heat.

As regards the handling and maneuvering of the turbine, it is much simpler and less hazardous than with reciprocating engines. There are no drains which, if forgotten, might knock out a cylinder head. The time required for "warming up" is much less, for steam has access to all parts at once. This, of course, is of great advantage when standing by for departure or "up anchor." The high-pressure turbine, in the prevailing arrangement of three turbines, is not touched at all in maneuvering or getting away, and it is the first to be shut off on an arrival "stand by." Sometimes this turbine has no separate telegraph control for taking orders from the bridge, the engineer simply turning it on when he gets his jingle for right away. When fitted with a telegraph there are no "go astern" signals, of course, and such a telegraph dial looks odd at first sight.

The low pressure turbines are the only ones fitted with reversing blades, and so, of course, are the only ones worked to bells. Their operation is very simple, for the levers are arranged so that the cut off from the high pressure turbine is automatic. When maneuvering, the engineer has to depend on the governor balls to show when the turbine moves for there is nothing visible to correspond with the numerous moving parts of the reciprocating engine. The turbines start quite promptly on the inlet of steam, and soon speed up. The regulation of speed according to orders is done by maintaining given pressures in the steam pipes. When shut off, the turbines do not stop so promptly, for the inertia carries them around until overcome by friction. For a quick stop the steam is turned into the astern side to help bring up the turbines. In case of a sudden order from "full ahead" to "full astern," the steam is instantly switched from the ahead to the astern blades, with no thought of the racking that would occur to reciprocating engines if they were treated thus. The turbines soon bring up under such treatment and in a few seconds are running just as fast astern. The smaller propellers, of course, are not so hard to reverse as would be the larger ones of a reciprocating engine, and, conversely, do not take such a grip on the water. That is, they start a column of water in movement promptly enough, but it is not of large diameter, and is not so quickly felt by the ship.

Much attention is being paid to this reversing feature of the turbine propeller. Recent turbines are built with almost as many go astern blades as they have on the go ahead side. They are on a smaller radius, the expansion is not so complete, but they use high pressure steam and the power is there, even if not quite so efficient. The result is that turbine ships can now stop about as quickly as any other. For maneuvering it must also be borne in mind that the turbine propellers are set away out from the center line of the ship. This gives a greater turning moment in case of swinging the ship about.

There are arguments on both sides of this turbine question, all of which may appeal differently to different engineers. Here is about the way they line up to the men who run them:

ADVANTAGES.

More room in the engine room, especially head room.

No moving parts exposed. Consequently no danger of getting caught, due either to lack of care, or to accident, and no oil thrown around.

No vibration of the ship, hence pipe hangers, joints, etc., do not shake loose.

Lighter shafting in engine and alleys.

Balanced thrust; smaller bearing and less heating of same.

Foundations of the engine lighter and more accessible.

No oil carried through to boilers, and oil saved due to increased efficiency of application.

No danger due to foaming or priming of boilers.

Less attendance required on engines, nearly everything being automatic.

Better immersion of smaller propellers, hence no racing in a sea way.

Less steam pressure. High vacuum is easier and more comfortable to handle than high steam.

Turbines easily turned when cold, and less likely to need it.

DISADVANTAGES.

Moving parts not accessible and not visible, so you don't know what is going on inside.

Auxiliary machinery larger and more important, hence more care.

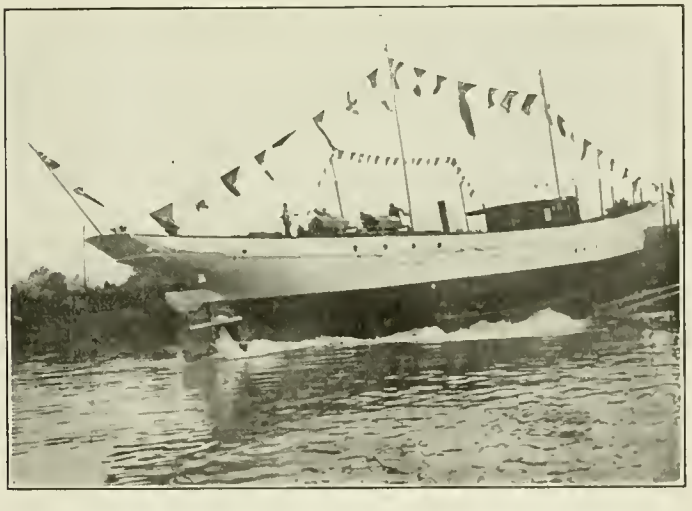
More dependence on automatic lubricating system for bearings.

At least one more line shaft to care for, and all of them at higher speed and more apt to run hot.

Main casings and rotor very heavy to handle, and great care required even with best appliances on new ships.

Danger of disablement by unseen causes among the blades.

Difficulty in making repairs to blades.



THE LAUNCHING OF STEAM YACHT BRANWEN.

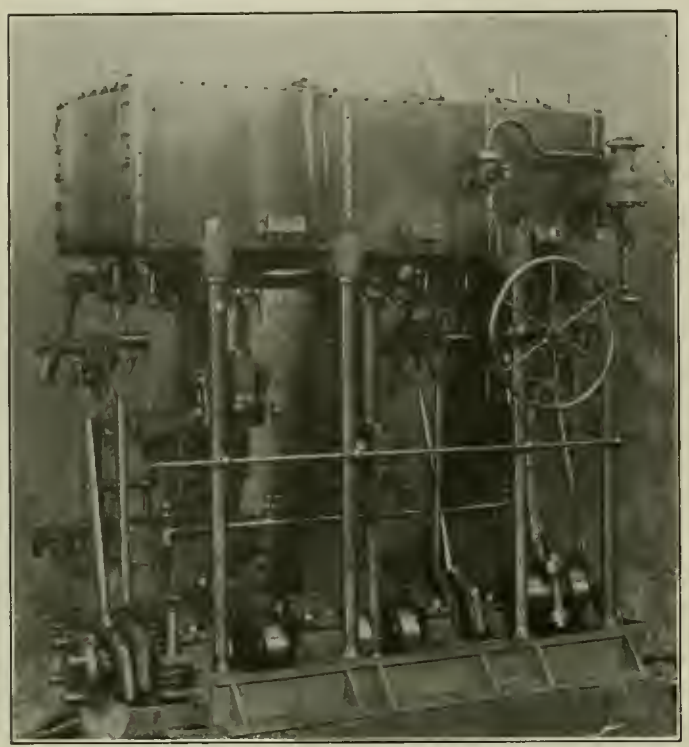
THE STEAM YACHT BRANWEN.

For Lord Howard de Walden, the English shipbuilders J. I. Thornycroft and Company launched recently the steam yacht *Branwen*, the first built at their new Woolston (Southampton) Works. The principal dimensions of this yacht, which has been constructed to Lloyd's highest class and under special survey, are as follows:

Length over all	135	feet	0	inches
Length between perpendiculars	111	"	6	"
Length on load water line	108	"	0	"
Breadth molded	16	"	6	"
Depth	11	"	3	"

The yacht is of steel with handsome scroll figurehead and trail board, quarter badges, etc; the design being oak leaves and acorns in relief and embodying the owner's armorial bearings. She is rigged as a fore-and-aft schooner with two pole masts.

The machinery is situated amidships, and consists of a triple-expansion condensing engine, having cylinders 9, 15 and 25 inches in diameter with a stroke of 18 inches, and a cylindrical multi-tubular return tube boiler, having an inside diameter of 9 feet 7 inches, and a length of 8 feet 9 inches. It is constructed for a working pressure of 180 pounds per square inch, to Lloyd's requirements.



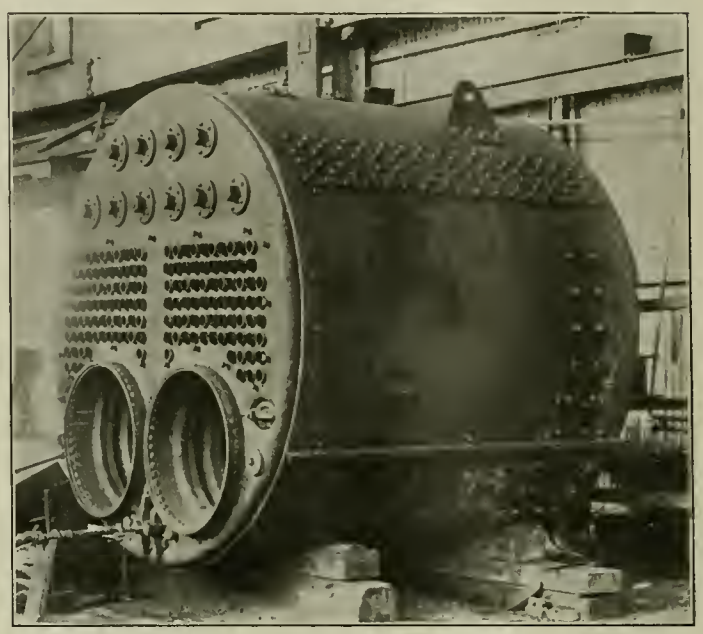
THE TRIPLE EXPANSION VERTICAL ENGINE.

THE YACHT AFLOAT, JUST AFTER LAUNCHING.

The decks and all skylights and fittings are of teak. A teak deck-house is situated at the fore end of the machinery space, and is arranged as a smoking room, a companion stair communicating with the accommodation below. The after end of the deck-house forms a bridge deck, from which the vessel will be steered by means of steam steering gear. An awning is arranged to be fitted over the raised deck.

The accommodation aft is entered by a sliding companion and ladder-way down to a roomy vestibule, with seats fitted up on either side, and with a door leading to the main saloon, which extends across the vessel. On the fore side of the saloon, and entered from same, is a lobby, with lavatory and bath room accommodation, and forward of this are two state rooms.

The forward accommodation consists of a deck saloon before mentioned, the stairway in same leading directly into the dining saloon below, which extends across the vessel. Abaft the saloon is the pantry on port side, and a bath room on starboard side. On the fore side of the dining saloon are two state rooms. This comprises the owner's accommodation. The after vestibule will be paneled in teak, the after lobby in light oak, and the remainder of the owner's accommodation enameled in white. The crew are berthed forward in the forecastle, with captain's and engineer's cabin abaft same.



THE TWO-FURNACE SCOTCH BOILER.

THE OWNER'S STATEROOM, STEAM YACHT BRANWEN.

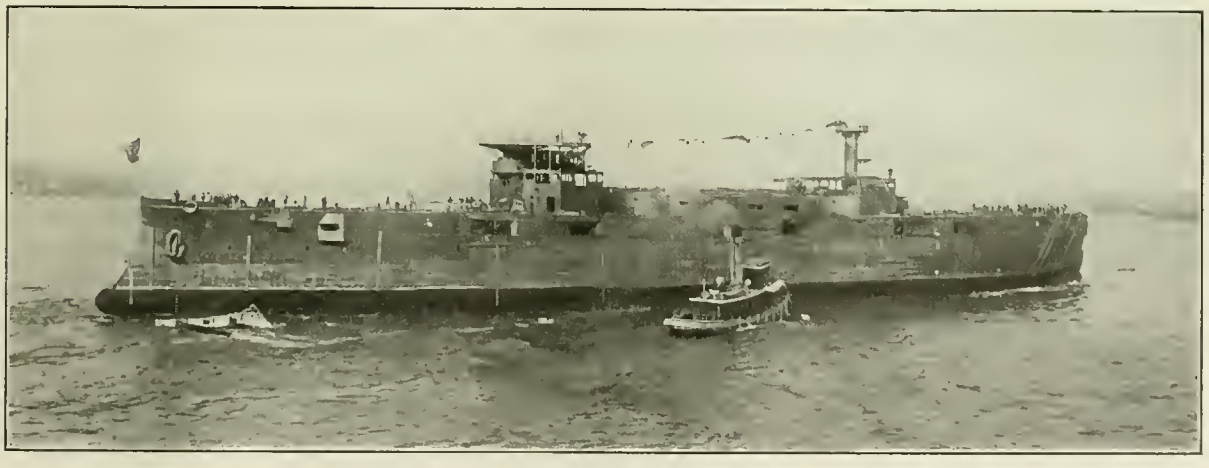
Fresh water tanks to hold 500 gallons of water are arranged forward and aft, with connections to pantry and galley. A hot water tank is fitted inside boiler casing to supply baths and lavatories, and a drain tank is fitted aft to take the waste water from

THE NEW STEAM YACHT BRANWEN, AT ANCHOR IN THE SOLENT.

pantry, baths and lavatories. The yacht will be heated throughout by steam, with radiators in the principal cabins. Two boats are to be carried in davits, a 20-foot gig, and a 16-foot cutter. Occasionally a 14-foot motor launch will be carried in place of the cutter. A steam capstan for working the cables, and warping the yacht is fitted forward.

square inch. The normal coal supply of 900 tons can be augmented to a full bunker capacity of 2,325 tons.

The battery is a very powerful one, including four 12-inch rifles in pairs in turrets on the center line forward and aft; eight 8-inch rifles in pairs in turrets on the broadside; and twelve 7-inch rapid-fire guns in an armored casemate. The



THE BATTLESHIP NEW HAMPSHIRE AFLOAT, AFTER BEING LAUNCHED INTO THE DELAWARE.

LAUNCH OF UNITED STATES BATTLESHIP NEW HAMPSHIRE.

On June 30 the battleship *New Hampshire*, under construction at the yard of the New York Shipbuilding Company, Camden, N. J., was successfully launched. The ship has a length of 450 feet, a beam of 76 feet 10 inches, and with a draft of 24 feet 6 inches will have a trial displacement of 16,000 tons.

Propulsion is by twin screws actuated by two four-cylinder triple expansion engines of a combined indicated horsepower of 16,500, the corresponding speed being 18 knots. The cylinder diameters are 32½, 53 and two of 61 inches, with a common stroke of 48 inches. Steam is supplied by a battery of twelve Babcock and Wilcox boilers, at a pressure of 250 pounds per

secondary battery includes twenty 3-inch rapid-fire guns and twenty-two smaller pieces, besides four 21-inch submerged torpedo tubes.

The armor includes a water line belt 9 inches thick, heavy barbettes with a maximum thickness of 11 inches, reduced to 7½ and 6 inches where protected by side armor; 8-inch barbettes with a thickness of 6 inches in the front and 4 in the rear; heavy turrets 12 inches thick in front and 8 in the rear; 8-inch turrets with thickness of 6½ and 6 inches. The protective deck, extending the full length, is 3 inches thick forward and aft, and amidships the slopes are 3 inches thick and flats 1½ inches.

The act authorizing the construction of the *New Hampshire* was approved April 27, 1904, and the contract was awarded December 27, 1904, the price being $3,748,000, this figure

covering hull and machinery. The keel was laid May 1, 1905, and the contract calls for completion February 27, 1908. The complement includes 41 officers and 840 men.

The *New Hampshire* is a sister ship to the *Minnesota, Louisiana, Connecticut, Kansas* and *Vermont*. Descriptions and illustrations of these ships will be found at pages 450, October, 1904; 489, November, 1904; 251, June, 1905; 429, October, 1905; and 165, June, 1906.

Errors in Naval Engineering Calculations.

BY CAPTAIN A. TROMP.

In comparing ships of different navies, very frequently—rather too frequently—errors are made; some of which, at the request of the Editor of International Marine Engineering, I will point out:

Horsepower.—One English horsepower = 1.01389 metric horsepower; or one metric horsepower = 0.9863 English horsepower. The result of this difference is that the transfer of a coal consumption of say 1 pound per English horsepower to metric weight, cannot be based on the fact that 1 pound = 454 grammes. It is more—1 English pound per English horsepower = 460 grammes per metric horsepower. Very often 500 grammes are taken. So, for instance, on page 351 of Vol. XVI., *Journal American Society of Naval Engineers,* the consumption of the *Amiral Aube* per unit of power was given as 588 grammes (1.17 pounds), whereas it ought to be 1.28 pounds. The limits were 1.63 to 1.74, and not 1.5 to 1.6 pounds.

The table on page 460 of the same volume is based on 1 pound to 447 grammes: therefore, the coal consumption in pounds is given too high.

Displacement.—One English ton = 1.0162 metric ton; or 1 metric ton = 0.9842 English ton. This difference has to be taken into consideration in calculating certain coefficients of fineness.

Length Between Perpendiculars.—English perpendiculars are entirely different from American and also from French. In the United States and French navies the after perpendicular goes through the intersection of the ship's hull with the water-line. The forward perpendicular in the United States Navy goes through the intersection of the sheer with the water-line, as against in the French Navy through the point of the ram. In the English and most of the other navies the forward perpendicular is taken as in the United States Navy, but the after perpendicular goes through the stern post; in other words, it defines the real under-water body of the ship.

In order to make a fair comparison between ships, it is evident that everything has to be based on the same standards. According to the American principle of perpendiculars, the ratio between length and beam in the *Colorado* and *Washington* are respectively 7.22 and 6.89. The English *Devonshire* and *Duke of Edinburgh* have a ratio of respectively 6.56 and 6.53; but applying the English principle to the American ships the ratios in the latter would be 6.99 and 6.67.

For the French Navy, very high ratios may be found, but brought back to the English principle they do not show anything extraordinary.

	American Perpend.	French Perpend.	English Perpend.
Colorado	7.22	...	6.99
Washington	6.89	...	6.67
Devonshire	...	...	6.56
Duke of Edinburgh	...	...	6.53
Jeanne d'Arc	...	7.50	7.09
Dupleix	...	7.30	6.94
Condé	...	6.83	6.58
Leon Gambetta	...	6.85	6.61
Ernest Renan	...	7.30	7.02

It is, therefore, evident that ship data as found in the usual handbooks, like *Brassey, Jane, Clowes, Durassier,* etc., are misleading, and they are the more misleading when they are used for figuring out certain coefficients of fineness.

Coefficients of Fineness.—Even assuming that all data about ships are based on the same standards, the usual coefficients of fineness do not furnish a basis of comparison. They are absolutely misleading. I know only one coefficient which gives a good idea of the under-water form of the ship. The formula is: $\frac{\text{Beam}}{\text{Length}} \times$ Cylindrical coefficient of fineness. I will illustrate this with the following coefficients.

	Block.	Midship.	Cylindrical.	$\frac{B}{L} \times$ Cyl.
Colorado	.5883	.9535	.6170	0.0883
Washington	.5732	.9507	.6029	0.0904
Jeanne d'Arc	.5478	.8223	.6661	0.0940
Dupleix	.4842	.7782	.6223	0.0897
Condé	.5190	.8399	.6179	0.0939
Leon Gambetta	.5246	.8565	.6125	0.0926
Ernest Renan	.5193	.8573	.6058	0.0863

CHECKING OFF DATA FROM EVAPORATION TESTS.

The following formula is of practical use for checking off data from evaporation tests of boilers:

When A = ratio of heating surface to grate surface,

B = pounds of water evaporated per hour per square foot of heating surface,

C = pounds of coal burned per hour per square foot of grate surface,

D = pounds of water evaporated per pound of coal burned,

then $A \times B$ must equal $C \times D$, because:

$$\frac{H.S.}{G.S.} \times \frac{\text{Water per hour}}{H.S.} = \frac{\text{Coal per hour}}{G.S.} \times \frac{\text{Water per hour}}{\text{Coal per hour}}$$

or,

$$\frac{\text{Water per hour}}{G.S.} = \frac{\text{Water per hour}}{G.S.}.$$

The usefulness of this formula can be demonstrated by the following data:

Nielausse Boiler (1904 Report, Bureau of Steam Engineering, U. S. N.). Test No. 1 (page 922),

$A \times B = 40.96 \times 6.27 = 256.82,$
$C \times D = 20.8 \times 12.41 = 258.13.$

Now C was not = 20.8, but 20.7, and now we get $C \times D = 256.87$, which checks with $A \times B$.

Babcock and Wilcox Boiler (1904 Report, Bureau of Steam Engineering). Test No. 4 (page 910),

$A \times B = 41.91 \times 7.85 = 329.00,$
$C \times D = 28.56 \times 11.09 = 316.73.$

Now B was not = 7.85, but 7.56, and now we get $A \times B = 316.67$, again checking with $C \times D$.

A mistake has been made in line 45, which is line 44 divided by line 2, or 283.031 ÷ 8 = 35.378, and not 35.125. Even with this figure of 35.125, the 7.85 is a mistake, as 35.125 ÷ 4.682 = 7.50.

Babcock (Cincinnati) Boiler (Babcock and Wilcox Handbook). Test No. 9.

$A \times B = 41.74 \times 6.47 = 270.06,$
$C \times D = 20.72 \times 12.22 = 253.20,$

but $B = 6.07$ instead of 6.47, and now we get $A \times B = 253.17$.

Test No. 8,

$A \times B = 41.74 \times 9.43 = 393.6,$
$C \times D = 34.03 \times 11.45 = 389.65,$

but $D = 11.57$ instead of 11.45, and now we get $C \times D = 393.65$.

Test No. 4,

$A \times B = 41.74 \times 8.75 = 365.23,$

$C \times D = 32.18 \times 11.5 = 370.00$,

but $C = 31.75$ instead of 32.18, and now we get $C \times D = 365.10$.

The above tests are based on combustible, equivalent evaporation from and at 212 degrees, etc.; but we can also take B' = pounds of water fed to boiler per hour per square foot of heating surface, C' = pounds of coal fired per hour per square foot of grate surface, D' = pounds of water as fed to boiler per pound of coal as fired; in other words, data which can be obtained in the regular service, doing away with analysis of coal, quality of steam, and factor of evaporation.

For instance, among the twelve evaporation tests made in December, 1903, under such circumstances, on board the Dutch armored ship *Hertog Hendrik*, I found one which gives $D' = 7.82$, whereby 259.71 is equated to 279.97, but 13,976.7 pounds of water divided by 1,926.84 pounds of coal = 7.254, and now we get $259.71 = 259.71$.

One more and rather striking example:

Belleville (*Hyacinth*) *Boiler* (Naval Progress, No. XXI., page 289).

The 8,000-horsepower and the full-power trials were said to have given the following data (Ratio, $30.88 = A$.):

B	*C*	*D*	*AB*	*CD*
6.38	19.8	9.39	197.04	185.93
7.78	27.2	8.28	240.25	225.21

Here the data of water per pound of coal are absolutely wrong, for:

147,190 water ÷ 14,930 coal = 9,859, and not 9.39,

190,210 water ÷ 21,515 coal = 8.840, and not 8.28.

Also, figuring out the other data more correctly, we now get:

6.380	19.99	9.859	197.04 = 197.04.
7.787	27.20	8.840	240.47 = 240.47.

This formula, therefore, gives a simple means for discovering arithmetical errors in evaporation data, and that it is needed is proved by the facts mentioned above.

LAUNCH OF TURBINE STEAMER "VIPER."

BY ALLAN M'PHERSON.

The Fairfield Shipbuilding and Engineering Company of Glasgow launched from their yard on March 10 the steamer *Viper*, the first turbine vessel built for the Irish Channel service. With the advent of this fast steamer, the time occupied in the journey between Scotland and the popular tourist resorts in Ireland will be considerably reduced. The *Viper* will take the place of the paddle steamer *Adder* in the daylight service between Ardrossan and Belfast. The adoption of turbines in the *Viper* goes to show that this type of engine has been proved to be the most efficient for high speed traffic, and in addition the most comfortable for the traveling public, as it reduces vibration to a minimum.

The new steamer will be unequalled on any cross channel service in the kingdom. She is guaranteed to maintain a speed on service of 21 knots, and is of the following dimensions:

Length between perpendiculars	315 feet 0 inches
Breadth molded	39 feet 6 inches
Depth to promenade deck	24 feet 0 inches

STERN VIEW OF TURBINE STEAMER VIPER ON THE WAYS, SHOWING THE THREE PROPELLERS.

Gross tonnage	1750
Horsepower	6500

She is constructed throughout of mild steel to Lloyd's highest classification for channel service, and to Board of Trade requirements for passenger certificate. In accordance with the most recent developments in passenger steamer design, the accommodation for first class passengers has been arranged forward of amidships, and the second class accommodation is aft.

On the promenade deck are the entrance halls, the first class smoking room, tea room and state rooms. On the main deck forward is the first class main saloon and first class ladies' cabin, while aft on the same deck is the second class main saloon, also the crew's quarters. On the lower deck are the dining saloons; that for first class passengers is 78 feet long and has seats at tables for 125 diners, while the second class saloon aft has seats for 105 diners. The vessel will be steered by a balanced rudder aft, and in addition she has a bow rudder for use in navigating the narrow harbor at Ardrossan.

The propelling machinery consists of three independent Parsons compound steam turbines and two condensers. There are

two low pressure turbines and one high pressure turbine, each driving a separate shaft with one three-bladed propeller on each shaft.

The condensing water is circulated through the condensers by two large centrifugal pumps. The engine room will be fitted with all modern appliances, including a large feed filter and suitable feed heater.

Steam will be supplied by four double-ended boilers of the ordinary multitubular marine type, fitted with Howden's forced draught. The turbines and other machinery have been constructed by the Fairfield Company. With the low pressure turbines are incorporated the reversing turbines, with which the vessel, when going full speed, can be stopped in one minute and a half.

THE VIPER ON THE WAYS, JUST PREVIOUS TO BEING LAUNCHED.

TRIALS.

The trials of the *Viper* on the Clyde deserve some notice here. This vessel has a straight stem, a tumble home stern, long upper promenade deck with steel shelters forward, two light pole masts and two funnels. She carries 1,700 passengers.

The series of trials were carried through without a hitch. They consisted of preliminary spins, a series of runs on the measured mile at Skelmorlie at uniformly progressive speeds, six double runs between the Cloch lighthouse and Cumbrae lighthouses at full speed, a stopping trial from full speed, and three runs backwards at full speed on the measured mile. On all these trials the *Viper* was loaded with coal and pig iron, so as to represent as nearly as possible her actual service condition, and the results aimed at were largely exceeded. A speed of over twenty-two knots was reached and the contract speed of twenty-one knots was obtained with natural draught only, although ½ inch air pressure was allowed by the contract. The run from Ardrossan to Belfast will therefore be done in about 3½ hours.

From full speed ahead the vessel was brought to a dead stop in one and a half minutes. A speed of 14½ knots astern was recorded, without forcing the astern turbines to their full power. Anchor and electric light trials were also successfully carried out.

B. T.

The Dry Dock Dewey reached her destination in Olongapo Bay, Philippine Islands, on July 10th.

Engineers in the Navy.

In the course of his remarks upon a paper by Fleet Engineer W. J. Harding, R. N., entitled "The Defense of the Realm," Lieutenant Carlyon Bellairs, R. N., M. P., had occasion to refer to the present attempt to make naval officers "Jacks-of-all-trades." He said, in part:

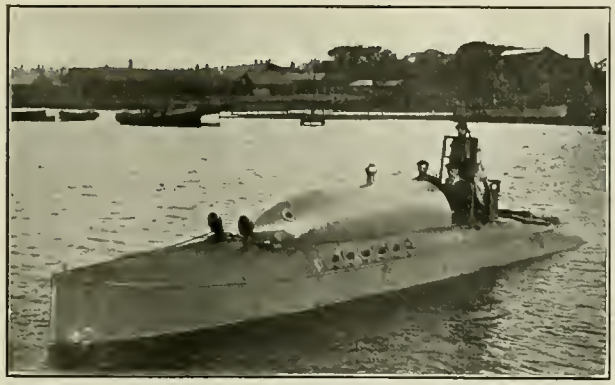
The moment we had one profession including both engineering and seamanship we had this trouble—that, having entered the service with the idea a boy had of becoming a Nelson, that idea would remain with him all his time, and when he was down on the engine-room platform he would have both eyes on the bridge, instead of devoting his attention to that great and noble profession of engineering, as he should do. We have seen that occur in the American navy. Before 1900 the Americans started the business of one officer doing all the jobs. One of the heads of the engineering profession last year reported that the result has been this—that the American navy was unfit to go to war! That was a very serious statement for the head of the engineering profession to make, but it seemed to be borne out by what occurred in the American warship *Bennington*. That disaster disclosed an extraordinary state of affairs. There was a young officer, a direct product of that system of learning seamanship, gunnery, and engineering all in one, in charge of the engines. He did not bother about the safety-valve being tested. When the ship got up steam a man was told to shut an air-cock. He closed a cock which shut the pressure-gauge off one of the boilers. That pressure-gauge continued to register zero, although the pressure-gauge on another boiler was accounting for another pressure. Stoking went on, and by-and-by that boiler burst, which resulted in the other boiler bursting as well, and there was a most appalling loss of life on board. The casualty was all the outcome of the attempt to create a "Jack-of-all-Trades"—a "handy Billy"—who was a man of no trade at all.

The Fast Motor Boat Brooke I.

Our photograph gives an idea of the general appearance of a recent production of J. W. Brooke & Company, Limited, Lowestoft, England, the boat being 39 feet 9 inches long and 5 feet 6 inches wide. She is fitted with a double mahogany skin built diagonally and very smooth.

The engine, which has six cylinders, measures 10 inches bore by 8-inch stroke, and operates a 6-throw crank shaft, 3¼ inches

in diameter, and forged solid from nickel-steel. The cylinders are bolted to a cast steel crank chamber, made in two parts, and the power (350 horsepower) is transmitted to the propeller shaft by means of a double ring expanding clutch 12 inches in diameter. The thrust is taken up by means of a Hoffman ball



BROOKE I.

thrust block. Ignition is by means of a low tension magneto machine. The propeller has a diameter of 22 inches, and runs at 900 revolutions per minute.

In spite of considerable difficulty with the carbureter fitted, the boat has been speeded up to 26 knots, and it is anticipated that with the difficulty removed a maximum speed of 31 knots will be possible.

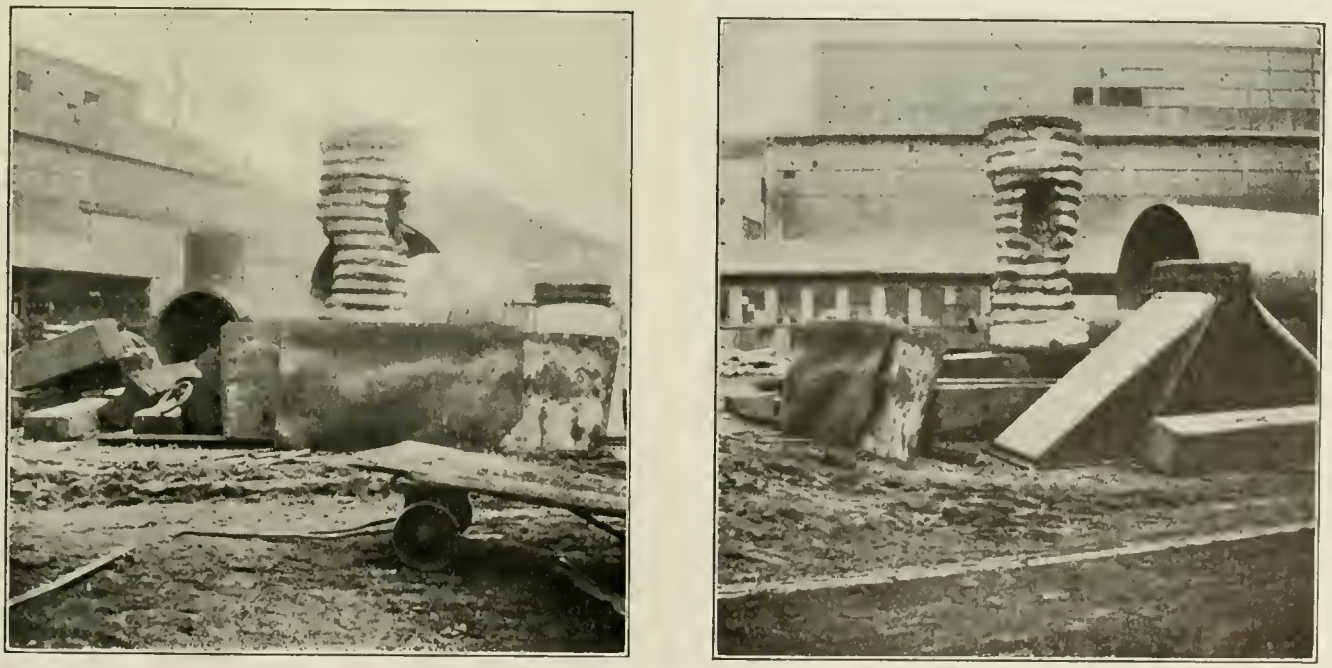
Flue Collapse on the Steamship Acme.

With only one Scotch boiler to furnish steam for her engine, the steamship *Acme* was recently in a very perilous position in stormy weather on the Pacific, near San Francisco harbor. The furnace on the port side of the boiler opened a crack, which made it necessary to draw fires and thereby, of course, stop the engines and the progress of the vessel.

The accompanying illustrations show the damaged flue, which was removed from the boiler for the purpose of putting in a new one. On examination of the boiler flues, scale more than ½ inch in thickness was found, which readily accounts for the disaster, although the steam pressure was at the relatively low figure of 100 pounds per square inch. The boiler was fitted for oil burning, and the flues have a diameter of 40 inches.

A CLOSER VIEW OF THE FLUE.

The three hollows forced into the weakened flue are of very considerable size, one of them having been 17 inches wide and 30 inches long, with a depth of 14 inches and a crack ½ inch by 3 inches across the bottom; another, 18 by 40 inches and 15½ inches deep; and the third 24 by 30 inches and 15¼ inches deep. These came in such positions as to stop up the flue passage to such an extent that an ordinary sized man would have had difficulty in crawling through to the combustion chamber.



TWO VIEWS OF THE DAMAGED FLUE, AFTER ITS REMOVAL FROM THE BOILER.

INTERNATIONAL MARINE ENGINEERING

Published Monthly at

17 Battery Place - - NEW YORK

By MARINE ENGINEERING, INCORPORATED

H. L. ALDRICH, President and Treasurer

8 Finsbury Square - - London, E. C.

E. J. P. BENN Director and Publisher

PROF. W. F. DURAND, Advisory Editor

SIDNEY GRAVES KOON, Editor

GEORGE SLATE
Vice-President and New York Representative

Branch Offices: Philadelphia, Pa., Machinery Dept., the Bourse, S. W. Anness.
Boston, Mass., 170 Summer St., S. I. Carpenter.
Chicago, 34 Clark Street, Howard S. Moss.
Midlands, 2 Sandhurst Road, Moseley, E. E. Starke.

TERMS OF SUBSCRIPTION

	Per Year	Per Copy
United States, Canada and Mexico	$2.00	20 cents
Great Britain and Ireland	10/6	1/
Other countries in the Postal Union	10/6	1/

Entered at New York Post Office as second-class matter.
Copyright, 1906, by Marine Engineering, Inc., New York.
International Marine Engineering is registered in the United States Patent Office.
Copyright in Great Britain: entered at Stationers' Hall, London.

Notice to Advertisers.

Changes to be made in copy, or in orders for advertisements, must be in our hands not later than the 5th of the month, to insure the carrying out of such instructions in the issue of the month following. If proof is to be submitted, copy must be in our hands not later than the 1st of the month.

The Speed Supremacy of the Atlantic.

On June 28 began what has been universally considered to be a race between two of the most prominent of the high speed liners covering the passage of the North Atlantic. The result of this race was almost a foregone conclusion because of the fact that the *Deutschland,* of the Hamburg-American Line, with its quadruple expansion engines of an aggregate of 37,000 indicated horsepower, holds the time record for the fastest passage across the Atlantic; although another German ship, the *Kaiser Wilhelm II* of the North German Lloyd Line, has made a slightly longer passage at a slightly higher rate of speed. The other contestant in the race was the new French Line flyer *La Provence,* fitted with four-cylinder triple expansion engines which developed on trial a little over 30,000 horsepower.

The best transatlantic passage of the *Deutschland* was made at a higher rate of speed than the trial trip of *La Provence,* and the German ship, having a higher freeboard forward, is much better capable of battling with heavy weather than is her French rival. On the other hand, the French ship was on her third return passage across the Atlantic, and her bottom was presumably in very good condition as compared with that of the *Deutschland,* which had not been in dock for many months, and was probably pretty foul.

The contest for the best Atlantic speed began long before the days of steam propulsion, and will persist long after steam has been supplanted by the next motive element in point of historical order. The only very definite information which can be obtained upon the subject at the present time, however, is concerned with the contest as among the numerous steam-propelled ships which have been in the service during the past sixty or seventy years. It is only within the last twenty-five years that a passage has been made at a rate of speed higher than 19 knots, the present highest record being a trifle more than 23½ knots. The first ship to cross in less than six days made her record-breaking passage as recently as 1889, and it is only within the last six years that any ship has covered the trip at a rate of as much as 23 knots. The end, so far as present indications go, and referring solely to ships propelled by steam, is not apparent, for the Cunard Line has just launched two ships destined to take from the Germans, for the time being at least, the honor of maintaining upon the service the fastest ships afloat. It is rumored that one of the German lines is about to undertake the construction of a ship which shall exceed in both size and speed the new Cunarders. The rivalry is very keen, particularly when, as in the particular case under consideration, it assumes an international aspect.

Ineffective Armored Cruisers.

In another column we are publishing an extended description of the trial trip of the new United States armored cruiser *St. Louis,* which has been turned out by the Neafie and Levy Ship and Engine Building Company of Philadelphia. This vessel and her sister ships are carried on the navy lists as protected cruisers, simply because the act of Congress authorizing their construction used that term. The ships were made much more powerful than was contemplated in the original act, and are in every sense of the word armored cruisers, although they are far from the highest type of such vessels.

It is natural, in considering the military qualities of a ship, to compare it with ships of about the same size and character, as they exist, either in effect or in design, in other navies. The ship in question is of almost the identical displacement of a series of ten ships in the British navy, five of which were members of the fleet which visited the port of New York last November. Not only is the size the same, but the main battery consists in each case of fourteen 6-inch

rapid fire guns. This great similarity in size and battery power lends itself readily to a comparison of the ships as a whole, and it is seen at once that the American design is decidedly inferior to the British, in spite of the fact that the British ships were some of them in the water before the American drawings were completed. In the first place, the English ships have a speed of at least one knot better than their American contemporaries, and in some instances the difference is much greater than this. This excess speed is attained, not at the expense of other qualities but simply and solely as the result of better design; for the horsepower developed in the two cases is about the same, and the superiority of the English vessel means very superior hull lines and more efficient propellers.

A still more striking comparison of the new American ships with those of another power is afforded by six of the armored cruisers of the Japanese navy, of which four were built in England and one each in France and Germany. These ships are of almost the same displacement as the American and English ships above mentioned, and the average speed is about that of the American ships. It is in battery power, however, that the Japanese show their immense superiority. All six carry four 8-inch guns in addition to the 6-inch battery. In two cases there are fourteen 6-inch guns mounted, this being the same number as on the English and American ships, while the other four Japanese vessels carry each twelve 6-inch guns. It is thus seen that each Japanese cruiser has a battery superior by four 8-inch guns, to offset which four of them lack two of the 6-inch size. The superiority in gun power is certainly not less than 50 percent, and, with increasing ranges of action, it is much more than this.

Not only are the Japanese ships more powerfully armed than the American, but they are also more effectively protected against the gun-fire of an opponent. Each of the ships has a belt 7 inches thick, and extending for about two-thirds of the length, as compared with which the American ships have only four inches of armor.

We have no doubt that as a construction, as a typical example of shipbuilding of a particular character, the *St. Louis* ranks very high. As a type of warship to be imitated, however, the design can scarcely be recommended.

Bids for New Battleships.

Bids were opened in the Navy Department June 23 for the construction of the battleships *Michigan* and *South Carolina*, and it was found that two classes of proposals had been made, the first covering simply the design as prepared by the Navy Department, while the other was the design of the builder, the latter in ten cases out of twelve calling for the installment of turbine machinery. A schedule of the various bids follows:

Bidders.	Dept. Plans.	Builder's Plans.
Wm. Cramp & Sons	$3,540,000.†	$4,100,000.
New York Shipbldg. Co.	3,585,000.†	3,900,000.*
		3,850,000.*
Union Iron Works	4,250,000.	
Newport News Co.	3,673,000.	3,813,000.
		3,713,000.*
		3,753,000.*
		3,963,000.*
Fore River Shipbldg. Co.		3,689,000.*
		3,719,000.*
		3,780,000.*
		3,820,000.*
		3,945,000.*

*Turbine machinery.

†Accepted.

The new ships are designed to be 450 feet long, with an extreme beam of 80 feet 2⅝ inches. The load draft at trial displacement of 16,000 tons is 24 feet 6 inches. The total bunker capacity is 2,200 tons of coal.

The battery consists of eight 12-inch rifles mounted in pairs in four turrets all on the center line, as illustrated by sketch diagram on page 255 of our issue for July. The secondary battery includes twenty-two 3-inch rapid fire guns; two 3-pounder and eight 1-pounder semiautomatic guns; four machine guns; two field pieces and two submerged torpedo tubes.

Armor protection is furnished by a water line belt of a width of 8 feet, and varying in thickness from 8 to 12 inches. Behind this belt will be a complete girdle of cellulose packing, designed to close up upon exposure to water admitted through a shot hole.

The department's design calls for propelling machinery of the four-cylinder triple expansion type, operating twin screws, and giving the ship a speed of 18 knots with 16,500 horsepower. The steam pressure in the high-pressure valve chest will be 265 pounds. Twelve water tube boilers in three separate water tight compartments are to have an aggregate of 1,050 square feet of grate surface and 46,750 square feet of heating surface, 10 percent of the latter being in the superheater; the ratio is 44.5 to 1. The working pressure is to be 295 pounds per square inch. The three funnels will reach 100 feet above the base line.

These ships represent the answer which the United States has made to the design of the *Dreadnought*. The broadside fire is the same; the forward fire, less; the after fire, greater. The speed is two knots less, accounted for by 2,500 tons less displacement. In spite of the considerably higher cost of ship-building in the United States, it is probable that each of these ships will cost less than will the English monster.

ABSTRACT FROM RULES AND REGULATIONS OF BUREAU VERITAS.

EDITION OF 1905.

ARRANGED BY HARRISON S. TAFT.

PART IV.

22. Shell Plating.

1. The midship scantling is to extend for ½ the length amidships. Forward and aft of said ½ length the plates may be gradually reduced in thickness as per table 6.

2. Shell plates are to be not less than 6 frame spaces in length. The difference in thickness between adjoining plates of the same strakes must not exceed ⅛ inch. The thickness at the ends of the garboard strakes and of the strakes of bottom plating adjoining same shall not be more than ⅛ inch less than the midship thickness of said respective strakes.

3. Boss plates on single screw steamers and the aftermost plates of the strakes below them must be of the same weight as their respective strakes amidships. Likewise all furnaced plates at bow and stern. The thickness of the two aftermost plates of the shell strakes from the boss plates to top of the propeller frame must not be more than ⅛ inch less than the midship thickness of the corresponding strakes.

4. With the machinery fitted aft, no reduction from midship weight will be allowed in the shell plating aft up to the counter.

5. Outside strakes are to have solid liners of the same breadth as the frame flange, fitted in one length between the plating and the frames. Bulkhead liners are to extend from the frame before to the frame abaft the bulkhead: or else efficient diamond plates are to be fitted.

6. Butts of the garboard strakes are to be well shifted from each other and from the keel scarphs. Those of adjoining strakes of the shell plating (also of stringer and deck plating) are to have at least a two frame space shift from each other. Two butts of the shell plating in the same frame space must not come oftener than on every third strake.

7. Compensation must be made for all doors, side ports or other openings cut in the shell plating. As far as possible it is best not to make any holes in the sheerstrakes.

8. When a continuous double bottom is fitted with the plates of same worked fore and aft, the shell plating (except the keel and garboards) entirely within said bottom space can be of reduced thickness. reductions must stop at a suitable distance from the ends of said bottom.

9. Bulwark plates are to be of the same weight as those of the upper part of hold bulkheads.

10. For vessels navigating in ice the bow plating from the stem to two frames abaft the forward collision bulkhead, between the light load water line and two feet above the deep load line, must be in thickness 1½ times the thickness of the midship plating, but it need not exceed one inch. Aft of this increased thickness the plating may gradually be reduced to regular thickness, but the difference between two adjoining plates of the same strake must not exceed ⅛ inch.

11. The main sheerstrake is to be worked at the upper deck in one, two and three deck vessels, but at both the spar and second decks in spar deck vessels.

12. See also sections 34, 35 and 36 for awning deck vessels, raised deck vessels, poops, forecastles and bridgehouses respectively.

TABLE 6.—THICKNESS OF SHELL PLATING AT ENDS.

(Beyond the ½-Length Amidships)

Thickness of Shell Plating for ½-Length Amidships.	32nds	Quarter Length	32nds	Thickness of Shell Plating for ½-Length Amidships.
	7	7-32nds	7	
	8	8-32 "	8	
	9	8-32 "	9	
	10	9-32 "	10	
	11	9-32 "	11	
	12	10-32 "	12	
	13	11-32 "	13	
	14	12-32 "	14	
	15	13-32 "	15	
	16	14-32 "	16	
	17	14-32 "	17	
	18	15-32 "	18	
	19	15-32 "	19	
		First Eighth / Second Eighth		
	20	16-32nds / 18-32nds	20	
	21	17-32 " / 19-32 "	21	
	22	17-32 " / 20-32 "	22	
	23	18-32 " / 21-32 "	23	
		First Twelfth / Second Twelfth / Third Twelfth		
	24		24	
	25	18-32nds / 20-32nds / 22-32nds	25	
	26	18-32 " / 21-32 " / 23-32 "	26	
	27	19-32 " / 22-32 " / 24-32 "	27	
	28	19-32 " / 23-32 " / 25-32 "	28	
	29	20-32 " / 24-32 " / 26-32 "	29	
	and Above	4-32 less than midship plates / 3-32 less than midship plates / 2-32 less than midship plates	and Above	

23. Butt Straps.

1. In general the butt straps of the sheerstrakes are to be worked in one length. In case the sheerstrakes extend above the gunwale bar sufficiently to allow of two horizontal rows of rivets above said bar the butt

straps can be fitted in two pieces, the part above the gunwale bar being $\frac{1}{16}$ inch thicker than if the strap had been worked in one piece.

2. With double butt straps, the one that is calked is to be in thickness 70 percent of that given in table 9, the other strap being 60 percent.

3. All butt straps of the masts, and yards and other spars are to be $\frac{1}{16}$ inch thicker than the plates they connect.

4. Butt straps are to be fitted to the butts of all doubling plates. Also to the butts of all continuous angle bar keelsons or stringers.

5. When butt straps are fitted to floor plates, center plate keels and keelsons, they are to be worked double.

6. Care must be taken to get a proper shift of the butts of all adjacent members.

7. All butts of keelsons, bilge and hold stringer angle bars or bulbs, are to have scarph pieces at least 2 feet long. Bulb angles may be have a lap equal to at least 2½ times the depth of the bulb, in lieu of strap or scarph pieces.

8. If an outside shell strake is butted in way of a bulkhead liner, a butt strap must be fitted to said butt in addition to the liner, but it can be in thickness ⅔ of what it ordinarily would be.

24. Riveting.

1. The thicker of two plates is to regulate the diameter and system of riveting used. The greatest thickness of the shell plating is to regulate the size of rivets used to secure the frames and reverse frames to said plating.

2. The system of riveting used in the longitudinal seams amidships is to be carried all fore and aft.

3. The longitudinal seams of the shell plating are to be chain riveted.

4. The riveting of butts of shell plates over 58 inches wide shall be specially considered.

5. In steam vessels with machinery placed aft the shell butts shall be treble or quadruple riveted at the after end if the same be required amidships.

6. When treble riveted butts are used amidships in screw steamers, the three after most butts in each of the shell strakes from the keel up to at least the deep load line are also to be treble riveted.

7. The riveting of doubling plate butt straps is to be the same as for other butts. They should be well riveted on their edges with extra rivets in the frames.

8. The keel plates and garboard strakes are to be connected to the stern frame by three rows of rivets when the thickness of these strakes respectively are $1\frac{1}{8}$ and $\frac{5}{8}$ inch: Also in high speed steamers. Tap rivets are recommended for one of the rows.

9. There are to be three rivets in each flange on each side of the butt of the scarph pieces to frames at center line.

10. Scarphs pieces to butts of reverse frames; to butts of floors and bilge keelsons; and to those of hold stringers are to have three rivets in each flange on each side of the butt.

11. Reverse lugs on frames and top of floors are to have at least a three rivet connection to same.

12. When the upper deck gunwale bar is 4 inches by 4 inches and over, double riveting (zigzag fashion) is to be used in both flanges.

13. Rudder rivets should not exceed one inch in diameter.

14. Rivet holes are to be punched from the faying surfaces.

15. Countersinking to extend at least through ⅔ of the thickness of shell and stringer plates.

16. The Following to be Single Riveted:

a. Longitudinal seams of plated decks.

b. Longitudinal seams of the tank top plating, including those of the center line and margin strakes when said strakes are under 15-32 inch thick.

c. Butts of deck plating at ends of ship where of or under $\frac{5}{16}$ inch thick.

d. Butts of the tank top plating outside of machinery space where of or under 11-32 inches thick.

e. Bulwark butts where of or under ¼ inch thick.

f. Seams of lower masts, bowsprits and polemasts when built with angle bar stiffeners.

g. Seams of topmasts and yards.

17. The Following to be Double Riveted:

a. The inner edge of the deck stringer plate in vessels of 400 feet or more in length.

b. Longitudinal seams of the bottom plating to upper turn of the bilge if said plating is or over 11-32 inch thick.

c. All longitudinal seams of the shell plating (including spar and awning decks top sides) if the side plating is or over $\frac{7}{16}$ inch thick.

d. Longitudinal seams of the sheerstrake and of a flat plate keel are to be double riveted when the adjoining plating is or over 11-32 inch thick.

e. Longitudinal seams of the tank top center line strake and of the margin plates whenever said strakes of plates are or over 15-32 inch thick.

f. Butts of floor plates with double strap.

g. Web frames to floors.

h. Side plated rudders.

i. Seams of lower masts built without angle bar stiffeners.

j. Seams of polemasts built without angle bar stiffeners to be double riveted to above lower mast hounds.

k. Butts of all spars (except as indicated under trebleriveted).

18. The Following to be Treble Riveted:

a. Butts of the first side plates in poops and raised quarter decks as well as those at the ends of bridgehouses.

b. Lapped butts of floor plates (three complete rows).

c. Butts of lower masts, top-masts, bowsprits (outside of wedging) and polemasts.

d. Butts of fore and main yards for the ¼ middle length.

TABLE 7.—RIVETING SCHEDULE. LAPPED AND STRAPPED BUTTS.

Thickness in inches of		Style of Riveting ½-Length Amidships Lapped or Butted Straps	Style of Butt Straps
Keel Plates; Garboards; Bilges; Upper, Main, Spar and Awning Deck Sheerstrakes, Stringers and Deck Plating; All top sides plating above the main deck; Bridge Platiog.			
Iron Rivets	Steel Rivets		
Under 13/32	Under 14/32	Double	Single
of 13/32 " 18/32	of 14/32 " 21/32	Treble	Single
of 19/32 " 24/32	of 22/32 " 27/32	Quadruple	Single
of and Over 24/32	of and Over 28/32	Treble	Double

Sides and Bottom of the Shell Plating			
In application of the above thickness to Side and Bottom Plating the thickness of same is to be reckoned as follows:			
Amidships		At Ends	
Iron Rivets	Steel Rivets	Iron Rivets	Steel Rivets
80% of the actual midship thickness	90% of the actual midship thickness	65% of the actual midship thickness	75% of the actual midship thickness

25. Double Bottoms.

1. The center line keelson must have a double angle bar connection to the tank top plating. Said keelson must be stiffened by bracket plates at each frame where no solid or bracket floor is worked.

2. Side longitudinals worked continuously throughout the double bottom space, and spaced not more than 4 feet apart, are to be located on each side of the center line, being secured to the shell and tank top plating by a single angle bar.

3. The tank top margin plates are to be secured to the shell plating by a longitudinal angle bar worked continuously, the frames being cut at said point.

4. The frames outside of the margin plates are to be secured to same by bracket plates of the same thickness as the flange of the frame. Inside of the margin plates those frames which have no solid or bracket floors fitted to them are to have a bracket plate connection to the margin plates. The brackets are to have a depth at the bilge equal to at least twice the depth of midship floors at center line.

5. Vessels of 22 and under 29 feet in depth are to have every fourth tank top frame bracket secured to the margin plates by double angle clips. Those of 29 feet or over in depth are to have every second bracket thus connected to the margin plates. All fore and aft in both cases. In single decked vessels every fourth frame is to be thus secured with depths ranging from 19 to 25 feet and every second bracket for depth of 26 feet and above. All web frames are to have double angle clips to said margin plates; but gusset plates may be fitted in lieu of said clips.

6. Floors cut at the center line girder are to have a double clip connection to same, when the width of said floors is more than ⅗ that of the midship floors and the vessel's beam exceeds 42 feet. When the beam is between 36 and 42 feet the clips are to be worked single and double alternately. In the machinery space and coal bunkers they are to be worked double throughout.

7. Double Bottoms with Floors on Alternate Frames.

a. When this type of construction is adopted bracket or solid manhole floor plates must be fitted intercostally between the continuous side longitudinals on alternate frames. Said floor plates must be of the same thickness as said longitudinals.

b. When the longitudinal number exceeds 450,000 solid manhole floor plates must be fitted in all cases.

c. In the engine room solid manhole floor plates must be fitted to every frame; in the boiler room to alternate frames; bracket floors not being allowed in either space.

d. With this type of construction floors must be fitted to every frame for 15 percent of the vessel's length abaft the fore peak bulkhead.

8. Deep Floor Plates on Every Frame.

a. Said floor plates are to extend in one piece from the center line to the margin plates.

b. A side longitudinal is to be worked intercostally between said floor plates, midway between the center line and margin strake on each side of the vessel: said longitudinal plates being ⅛ inch thicker than the floor plates.

c. Two such longitudinals are to be fitted if the vessel's beam at the tank top exceeds 34 feet.

d. Auxiliary longitudinal girders must be fitted in way of the machinery to suit condition of same.

e. Solid manhole floors are to be fitted throughout the machinery space as stated above (25-7-*c*).

f. This system of construction is recommended for vessels in which the center stanchions are omitted.

9. Longitudinal Girders on Top of Ordinary Floors.

a. Said longitudinal girders must not be spaced more than 4 feet apart or from the center line girder. The

side girders may be ⅛ less in thickness than the center line girder. They are to have a continuous angle bar on their upper and lower edges for securing said girders to the reverse bars on top of floors and to the inner bottom plating. The center line girder is to have a double top and bottom angle connection to the reverse bars on top of floors and to the inner bottom plating.

b. Bracket plates are to be worked so as to give sufficient athwartship strength to said double bottom.

c. The floor and lower bilge keelsons may be dispensed with in this type of construction.

d. If the double bottom does not extend the entire length of the vessel the center girder on top of floors must scarph the center line keelson, and the floor and bilge keelsons must extend for at least three frame spaces into said double bottom in order to maintain continuity of strength.

10. When a double bottom is worked under the boilers and engines, the floors under the boiler bearers and engine seating must be ⅛ thicker than otherwise. The tank top plating in the engine and boiler rooms, and in the cross-bunkers is to be of increased thickness.

11. When the bed plate of the engine rests directly on the tank top plating the thickness of the tank top plating under said bed plate must be twice that of the regular engine room tank top plating. The holding down bolts of the bed plate are to be tapped into the heavier plating, with nuts, washes and grummets worked on the underside.

12. When a double bottom extends through the machinery space the second floor from the after end of the engine compartment should be made solid and watertight so as to provide for a drainage well at said point. Means should be provided for thorough draining the top of the inner bottom plating.

13. Proper manholes are to be cut in all side longitudinals and between each side longitudinal in all solid floors so as to allow of free access to all parts of the double bottom. Those in the side longitudinals are to be well shifted from each other and from all butts of the tank top and longitudinal plating. The size of the manholes are to be such as to leave a clear plate surface all around equal to at least 2½ times the depth of the vertical flange of the frame angles. Those in the tank top plating should be at least 12 inches x 18 inches in the clear.

14. There should be at least 12 inches between the boilers and the tank top plating.

15. All boiler and engine foundations and all other foundations should be securely riveted to the main part of the vessel. Under no conditions will bolts be allowed.

16. Double bottoms should be divided by a sufficient number of watertight floors so as to provide stability in filling or emptying the tanks.

17. Double bottoms are to be tested before launching by a head of water equal at least to the deep load draft of the vessel. In no case shall the head of water be less than 8 feet above the crown of the tanks. All peaks are to be similarly tested.

18. Water Ballast Holds or Deep Tanks. In deep water ballast tanks it is recommended to adopt a center line longitudinal bulkhead well stiffened and well secured to the bounding bulkheads of said tanks.

26. Hatches and Deck Openings.

1. The coamings of hatchways on exposed decks are to stand at least 18 inches above the deck planking. The coaming of hatches on the decks below the weather deck need not exceed 12 inches in height. In vessels with a low freeboard, the coamings of upper deck hatches are recommended to be made at least 30 inches deep.

2. If a coaming is of or over 24 inches in height above the deck, or is of or over 16 feet in length, it is to be stiffened or made heavier than otherwise.

3. All hatch coamings must extend to the bottom of the beams. When the beams are fitted on alternate frames the coamings are to be secured to said beams by double clips.

4. Shifting beams, spaced not over 8 feet apart, are to be fitted to all deck openings when the length of said opening exceeds 12 feet.

5. One fore-and-after is to be fitted to all cargo hatchways. When said hatchways exceed 10 feet in width, two fore-and-afters are to be fitted for supporting the hatch covers.

6. When the length of a hatchway exceeds six feet, it is recommended to fit a web frame in the hold in way of the stanchion under the mid length of the fore and aft carling.

7. Hatchways over ⅓ the vessel's beam in width call for special consideration.

8. Engine and Boiler Room Hatchways and Casing.

a. Engine room skylights and boiler castings are to have their coaming plates stand at least 30 inches above the deck. On the upper decks of awning deck vessels, and on poops and bridgehouses, the height of said coaming may be but 18 inches.

b. The casing of the engine and boiler room hatchways is to extend from the second to the upper deck. The bottom of any door way in said casing must be at least 18 inches above the deck.

c. When the length of the engine and boiler room hatchways exceeds 7 frame spaces, the upper and second decks must be strengthened as stated in section 18, paragraph 1-*g*, for hatchways over 9 frame spaces in length.

27. Masts, Spars and Rigging.

1. Lower Masts.

a. The length of a mast for determining its scantlings is to be measured from the top of the upper deck beams (second deck in awning deck vessels) to the hounds.

b. When a lower mast is of 44 feet or more in length measured as above stated it must have angle stiffeners extending its whole length. At least 3 rows of stiffeners must be fitted if the mast is made of 2 or 3 strakes of plates, and 4 rows if four strakes are used. In no case need the thickness of said stiffener angles exceed the thickness of the mast plating at the partners.

c. Doubling plates 5 feet long are to be fitted at the wedging deck, and similar plates 1 foot long at the heel.

d. Lowermast check-plates are to be ⅛ inch thicker than mast plates at partners. Their fore edge is to be strengthened by an angle bar or otherwise; their upper edge by an angle bar worked around the mast.

2. Topmasts.

a. The length for regulating the scantling of the topmast is to be measured from the lower mast cap to the top mast hounds.

b. When said length is over 21 feet in square rigged masts two rows of stiffening angles must be fitted the whole length of said top masts. The flange width of said angle bars is to be ⅛ of the diameter at the top mast's heel, their thickness being the same as the plating at said point.

c. Doubling plates at least 2 feet long are to be fitted in way of the lower mast cap. Fid and sheave holes are to be strengthened by doubling plates at said points.

3. Polemast.

a When the lower and topmasts are made in one piece the length for determining its scantlings is to be taken as stated above for lower masts.

b. If the length of a pole mast from upper deck beams (second deck in awning deck vessels) to topmasts hounds exceeds 44 feet three rows of angle bar stiffeners should be fitted. When angle stiffeners are fitted to the lower part of a polemast they must extend up to the topmast head.

c. The diameter of a polemast at truss hoops shall not be less than the greatest diameter of the yard located at said hoop.

4. Yards.

a. The total length of a yard (excluding the arms) is to regulate its scantling.

b. When a yard is over 20 inches in diameter it is best to strengthen same by one row of angle bar stiffeners to each strake of plating in the round.

c. The plating is to be worked double at the truss hoops.

5. Bowsprits.

a. When built to take a flying jibboom the length for regulating the scantling of a bowsprit is to be taken from gammoning to the cap. When the bowsprit and jibboom are made in one piece or length, said length is to be measured from the gammoning to the end of the jibboom.

b. The bowsprit shall be strengthened by a vertical web plate connected by four angles to the bowsprit plating.

c. Doubling plates are to be fitted at the gammoning.

(*To be continued.*)

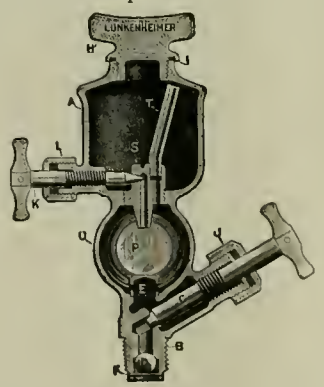
ENGINEERING SPECIALTIES.

The Premier Gas Engine Lubricator.

For the lubrication of gas or gasoline engine cylinders, the Lunkenheimer Company, of Cincinnati, O., has recently placed on the market a new device, illustrated herewith. The cup is made entirely of bronze composition; the construction is very compact, and the general design will appeal to users. The cup was constructed not only with a view to positive and proper lubrication, but also to readily withstand severe service. The filling hole is large, which users will appreciate, especially when the cups are applied to motor boat engines, as it permits the use of a filling can having a large spout. To positively insure a tight joint between the filling plug H, and top of cup, the cup is provided with a lead washer I, which material, being softer than the brass upon which it bears, will readily conform to any irregularity that might exist between these bearing surfaces.

The regulation of the feed is accomplished by means of the valve K, provided with a fine needle point, and the thread on the stem being also of fine pitch, a close adjustment can be obtained. The stuffing box L, not only serves the purpose of preventing leakage around the stem valve, but brings the proper amount of friction to bear on the stem, and thereby prevents the unsetting of the valve.

To provide against the back pressure interfering with the proper formation of the drops in the sight-feed, and causing the oil to spatter around the glass, the shank B is fitted with a large ball check valve D. It has been found, however, that where the back pressure is unusually great, as in engines with worn piston rings, the ball check does not entirely remedy the trouble. To meet this condition, a baffling cap E, has been provided just above the valve C. The gases escaping past the ball check D are effectually muffled and diffused by means of the cap E, and hence the drops form perfectly, drop freely and steadily, and the sight-feed glasses never fill up. Another feature is the construc-



tion of the sight-feed. This consists of the holder, retaining ring, two rubber washers, and the "bull'seye," made of a superior grade of glass, and very thick.

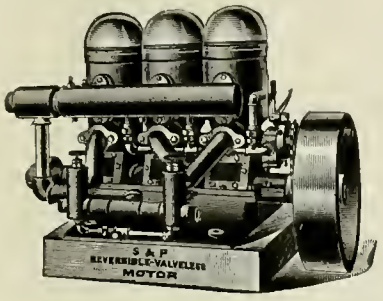
A Reversible Valveless Marine Motor.

A two-cycle engine with jump spark ignition, and of comparatively light weight, has been placed upon the market by Sittmann & Pitt, 213th street and Harlem river, New York. The water jacket around the cylinder being carried completely down to the crank chamber, insures a cool crank case on a long run, which means more power, as a greater volume of gas is then taken in and carried to the cylinder. The water enters at the bottom of the water jacket, and is carried completely around the cylinder and up into the head, then into the water jacket of the exhaust pipe, and a portion is allowed to enter the exhaust

pipe, forming a spray which further cools the exhaust gases, thus not only removing the back pressure but also most of the noise and odor as well.

The duplex pump supplies the water jacket of the engine and takes care of the bilge water.

The timer is of a new design, and makes a full and positive contact with a very rapid break, being especially adapted for a non-vibrating coil. In place of cams, hardened steel rollers of ample diameter are used to operate the vertical studs, which at their upper ends are set with platinum, no current being carried through the friction wheels.

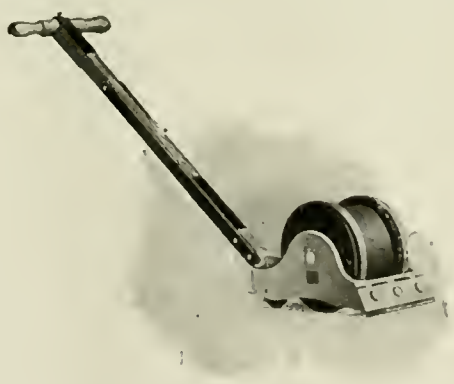


With the reversing lever, which is combined with the timing lever, the need of a reversing propeller is done away with, and a solid wheel of a true and correct pitch can thus be used. The engine runs in either direction. It is so easily started that it can almost be called a self-starting engine, a quarter turn of the fly wheel being all that is required on the double cylinder 10 horsepower. The hoods or caps on the heads of cylinders thoroughly protect them from short circuiting in rain or spray. Salt water fittings are used throughout.

The engines are built in single, double, triple and quadruple cylinders, representing 5, 10, 15 and 20 horsepower, respectively, and measure only 16½ inches high from center of shaft to top of cylinder head. Over all length on double cylinder 10 horsepower is 25 inches, including fly wheel, and weight is 340 pounds.

The Little Giant Floor Scraper.

Among the latest inventions placed on the market, which is of interest to all shipbuilders, as well as contractors and architects, is a machine for scraping and surfacing hardwood floors. This is an expensive, slow and laborious operation when done by hand, as it has always been done in the past, and in most cases unsatisfactory in results. A machine which saves time,



labor and money, while producing far superior work, leaving the floors smooth and even, without marks of any kind, is the "Little Giant" floor scraper, shown in the accompanying cut.

It is used successfully on any hardwood flooring, including oak, maple, birch, beech, yellow pine and parquet. No portion of the floor is beyond its reach, as it works right up to the base-board, and into all corners. High joints are quickly cut down, and the floor is left smooth and free from any marks of the knife. The machine is operated by one man, without additional motive power, and will do from three to six times as much work in a given time as the old hand method.

By the use of additional attachments, which are furnished by the manufacturers of the machine, the Hurley Machine Company, 153 South Jefferson Street, Chicago, floors are sandpapered and polished to perfection. For old floors there is another attachment, the use of which solves the vexing problem of redressing old worn floors. This removes all old varnish and filler, and puts the floor in prime condition, doing away with staining, liquid varnish removers or other substitutes which have been offered ineffectually for this work. The construction of the machine is said to be simplicity itself.

QUERIES AND ANSWERS.

All reasonable questions concerning marine engineering received from and signed by subscribers will be answered by the Editor in this column. All communications must bear the name and address of the writer.

Q. 350.—I have a pair of 7 by 28 inch stern-wheel plain piston valve engines with links, and an oil burning locomotive marine boiler of 350 feet heating surface, allowed 200 pounds steam working pressure in a 100 by 20 foot hull, draft 14 inches. The stern wheel is 11 feet 6 inches outside diameter by 12 feet. The engines, at ¾ stroke cutoff, turn up 30 to 31 revolutions. The slip is about 17 percent. The boiler makes sufficient steam to keep the pressure at 190 pounds to 200 pounds and feed water at about 180 degrees.

What would be the probable theoretical increase of power and speed and revolution with the same boiler and a pair of 8 inches by 42 inches automatic cutoff engines working at ¼ stroke cutoff, and the wheel increased to 12 feet outside diameter by 12 feet. Would the new take more or less steam?

The engine exhaust is into the feed water heater, and passing thence into the smoke stack.

A.—With your pair of 8 by 42-inch engines and cutoff at one-quarter stroke the probable increase in power per revolution with the same steam pressure and disposition of the exhaust would be some 25 to 30 percent. This should result in an increase of 10 to 12 percent in revolutions with the same wheel, and in a practically equal percentage increase in speed, and in a total increase of power developed of some 30 to 35 percent. At the same time, the steam required from the boiler would remain about the same, or might undergo a slight reduction.

With the larger wheel, about the same total increase in power and in speed would be realized, but at revolutions remaining nearly the same, or perhaps decreased by 4 or 5 percent.

So far as the relative amounts of steam required can be figured directly from the volumes of the two cylinders up to the point of cut-off and the revolutions per minute, it appears that the larger engine with earlier cutoff and increased revolutions would require some 20 percent less *volume* of steam than with the present arrangement. Such an apparent saving in steam must however be discounted by the increased effect due to cylinder condensation with the earlier cutoff, the exact amount of such loss depending on the various circumstances of the case, and admitting of only rough estimate with the information in hand. It is probable, however, that such loss would be less than 20 percent, and that there might result a total steam consumption less than at present by perhaps as much as 10 percent. On the other hand, if it is desired to drive the boilers as at present, and to use as much steam as with the present arrangement, then it is probable that the preceding figures for speed and total power developed may be bettered by one or two points. To such end, of course, the cutoff will be carried a little later than one-quarter stroke, and up to a point where the entire output of the boiler is worked off.

Q. 351.—Will you kindly inform me what is meant by suspending the link forward of the link arc, also what is the usual amount of angular advance given eccentrics on large and small engines? What are the

advantages and disadvantages of an eccentric with 100 degrees angular advance in comparison with an eccentric with 130 degrees angular advance? L. S. R.

A.—The link of a Stephenson valve gear is hung or connected to so-called side or bridle rods for the purpose of controlling its movements in reversing, linking up, etc. The point of attachment of these rods to the link may be either on the center line of the link arc drawn through the center of the link block, or at some point inside or outside of such center line. The effect of a change in the location of this point is to produce a change in the amount and character of the block-slip, or relative motion between the block and the link during the revolution. This in turn will have its influence on the character of the steam distribution, and by appropriate use of this influence the valve events and general character of the steam distribution may be made somewhat better equalized in the two ends of the cylinder than they would otherwise be. Whenever the point of attachment is thus located off the center line of the link arc, it is either for structural reasons and in disregard of the influence of such location on the character of the steam distribution, or it is to produce some desired influence on such distribution by the utilization of the modifying influence of the block slip as noted above.

A full discussion of these points will be found in our columns for June and July, 1905.

The purpose of a change in the angular advance of an eccentric is to produce a corresponding change in the timing of the various valve events relative to the position of the piston. Thus, with other things equal, a valve with 130 degrees angular advance instead of 100 degrees will open to steam earlier and have more lead, will cut off earlier, will open to exhaust earlier, and will close exhaust or begin compression earlier. Of course, the relation between the events on the admission and exhaust sides may be modified by changing the relative amounts of lap on the valve; but in general, a change in angular advance changes the time of the valve events relative to the positions of the piston.

The amount of angular advance varies widely according to the details of the steam distribution desired. The usual range may be put from 120 to 140 degrees, but there is no one figure which can be named as the "usual" value.

A full discussion of these points will be found in our columns for November, 1903.

TECHNICAL PUBLICATIONS.

Transactions of the Society of Naval Architects and Marine Engineers, Vol. 13, 1905. Edited by William J. Baxter, Secretary of the Society. Size, 8¼ by 11 inches. Pages, 395; plates, 201. New York, 1906. Published by the Society. Price, $10.

This consists of the eighteen papers and the discussions on same, read at the thirteenth annual convention of the Society, November 16 and 17, 1905. These papers were all outlined in our issue for December, 1905, and the gist of the discussions was there given. Several of the papers have been published in full in our columns.

Transactions of the American Society of Mechanical Engineers, Vol. 26, 1905. Edited by Professor F. R. Hutton, Secretary of the Society. Size, 6 by 9 inches. Pages, 841; figures, 292. New York, 1905. Published by the Society. Price $10, paper covers; $11, bound.

This includes the proceedings of the fiftieth and fifty-first meetings of the Society held respectively in New York and Scranton, and covers thirty-nine technical papers along the lines covered by the practice of the membership of the Society.

Information Guide for Transatlantic Travelers, 4th Edition. Size, 4 by 8¼ inches. Pages, 108; illustrations, 20. New York, 1906. The Frank Presbrey Company.

This little paper-bound volume, which can be readily carried in a coat pocket, gives a large amount of condensed information on subjects in which the ocean traveler is naturally interested. It contains maps of the principal harbors of Europe and the eastern coast of the United States, as well as a map of the North Atlantic ocean. There are given particulars of the principal ships of the leading transatlantic lines.

Water Softening and Treatment, By William H. Booth, A. S. C. E. Size, 5½ by 8½ inches. Pages, 308; figures, 102. New York, 1906. D. Van Nostrand Company. Price, $2.50 net.

The treatment of water for steam boiler and manufacturing purposes forms a question of great importance to the user of the steam or water, the main object being of course to reduce the amount of hard scale deposited in the boiler or the fabric. The subject is taken up in this book in five sections, of which the first and largest deals with the treatment of water by softening, together with the subjects of oil separation and filtration. The other four sections deal with mechanical methods of treating water, and with the apparatus required for such purposes. Of course the first section is largely a question of chemistry, and of the several forms of devices used in chemical softening. This part of the work, as well as that devoted more specifically to the mechanical method of caring for the water, is thoroughly illustrated, mostly by line cuts covering English and continental practice.

Under the mechanical head are taken up the subjects of heat, condensers, air pumps, circulating pumps, feed water heating, auxiliaries, water cooling by atmospheric evaporation, feed pumps, injectors, etc., and a number of tables are introduced giving the properties of the various substances used, as well as factors of evaporation, tables of solubility, and tables showing sizes and capacities of the various types of apparatus.

Things that Are Usually Wrong, By John E. Sweet. Size, 5¼ by 7½ inches. Pages, 52; figures, 50. New York, 1906. Hill Publishing Company. Price 50 cents.

Professor Sweet takes up a variety of devices in which in his extensive practice he had found errors in the usual method of handling the propositions under consideration. These errors are in the line of misconceptions of underlying mechanical principles, and relate to a great variety of items in connection with both steam engines and machine tools, including such auxiliary devices as pulleys, shaft hangers, etc. The aim of the book is, of course, to correct anything of the sort, by pointing out the defects of prevailing practice in such a way as to call attention to both the discrepancies and the proper remedy therefor. It is thus constructive as well as destructive in character, and is well worth careful perusal.

The Barritt-Serviss Star and Planet Finder. Collaborated by Leon Barritt and Garrett P. Serviss. Size, 15 by 15 inches, with pamphlet 9¼ by 6 inches. New York, 1906. Leon Barritt. Price $5.

This device consists of a chart of the heavens with all of the important fixed stars and constellations in proper position, the chart being arranged to rotate in such manner as to bring successively into view through an opening the portion of the solar system visible in the Northern Hemisphere, at any hour of the day or night, and for any day of the year. It is so arranged that the time of rising and setting of any of the stars can be ascertained sufficiently closely for ordinary purposes, while the positions of the planets, including the sun and moon, are set, by means of thumb tacks, upon the ecliptic from directions given in the pamphlet in such a way as to show clearly the time and setting of each one of the positions which it occupies among the constellations. The pamphlet gives tables covering the years from 1906 to 1925.

Beeson's Marine Directory of the North Western Lakes. Size, 6¾ by 9½ inches. Pages, 271; illustrations, 40. Chicago, 1906. Harvey C. Beeson, publisher, 251 Dearborn street. Price $5.

The present volume is the twentieth which has appeared, and is very similar to the last few numbers of this work, but is, of course, brought up to date in all respects. It contains a complete directory of all the steam vessels and sailing vessels on the

Lakes, including both American and Canadian craft, while under separate headings are the iron ore carriers, lumber vessels and particulars of boilers and machinery of the steam vessels on the Lakes. Statistics are given of the commerce through the Soo canals, and notes covering the transportation and steamboat lines. The illustrations are mostly half tones, and represent subjects of a wide variety of character, including passenger and freight steamers, steam and sailing yachts, marine machinery, lake, river, coastwise and ocean-going vessels, and a number of craft long since out of date, and interesting merely from the historical point of view. A map showing the new location of the New York State canal system is put in as a folder.

PERSONAL.

Chief Engineer John Quincy Walton of the Revenue Cutter Service has been nominated by the President as a constructor, so that his services may be at all times at the command of the service in connection with the design of new steamers, etc.

George I. Rockwood has been appointed Professor of Steam Engineering of the Worcester Polytechnic Institute, Worcester, Mass.

Charles E. Hyde, of Bath, Maine, has become president and general manager of the new organization of the New London (Conn.) Marine Iron Works. The new company has taken over the property of the old Morgan Iron Works, and, with additions contemplated, will have a complete plant for the repairing and outfitting of all classes of vessels.

Arthur W. Goodrich has been transferred from the Department of Construction and Repair in the Mare Island (Cal.) navy yard to the Department of Steam Engineering in the same yard, his capacity being that of draftsman.

Made in Germany.

At the time when the Hamburg-American steamer *Kaiserin Auguste Victoria* reached New York harbor on her maiden trip, there were in the harbor at that one time the largest steamship in the world, (the *Kaiserin*), which was built in Germany; the fastest steamship in the world, (the *Deutschland*, of the same line), which was built in Germany; and the largest sailing ship in the world, (the *Rickmers*), which was built in Germany; the This combination furnishes food for thought to Americans interested in shipping.

Shipbuilding in the United States.

The Bureau of Navigation of the Department of Commerce and Labor reports that during the fiscal year ending June 30, 1906, there were built in the United States a total of 1,079 sail and steam vessels aggregating 348,345 gross tons, as compared with 1,054 of 263,064 gross tons during the preceding year. In addition to this, there were built 384 unrigged vessels, such as barges, etc., of 73,399 tons, as compared with 247 in the preceding year, of 63,149 tons. The entire increase for the year is more than accounted for by larger construction on the Great Lakes, the figures being 239,448 tons in the present year, as compared with 103,550 in the preceding year. The falling off on the Atlantic and Pacific coasts aggregates 49,302 tons, or more than 30 percent.

The steel vessels propelled by steam amounted in the present year to 109 of 281,741 gross tons, as compared with 73 of 159,355 gross tons. In the present year nearly one-half in number and 84.4 percent in tonnage represent construction on the Lakes. There seems to be a decided falling off in the construction of wooden vessels propelled by sails, the tonnage having dropped from 72,730 to 33,327.

On the seaboard only two steamers for foreign trade have been built during the year, these being the *Mexico* and *Merida*, of 6,207 tons each, under mail contract for service to Cuba and Mexico, and built to replace two steamers sold to the Government for service to the Isthmus of Panama. Aside from these two only one ocean steamer of upwards of 1,000 tons was constructed.

The annual report of the Liverpool Steamship Owners' Association, for the year ending December 31, 1905, shows that the members of the Association owned at the end of the year a total of 3,524,426 gross tons of steam shipping, the net tonnage being 2,202,547 tons, and the number of vessels 857. The gross tonnage is stated to represent 21 percent of the total British steam tonnage afloat; 36 percent of the total number of steam vessels afloat having a speed of 12 knots and upwards; and 43 percent of the total number of steam vessels afloat of above 5,000 tons each. The average size of the vessels included is 2,570 tons net and 4,113 tons gross.

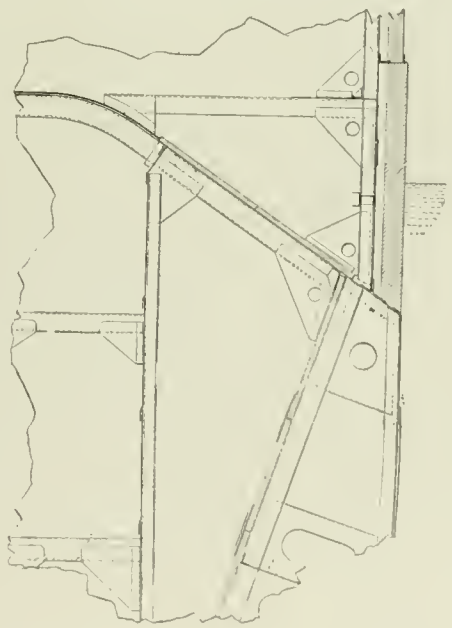
The statistical records given in the report show an almost steady increase in tonnage owned by the members of the Association, there being only three years since 1868 when the gross tonnage is smaller than at any previous year. In the year last mentioned, the tonnage was 310,669. It first passed the million mark in 1883, with 1,005,650 tons. The two-million mark was first passed in 1900, when the tonnage was 2,221,824; and the three-million mark in 1904, with 3,237,891 gross tons.

SELECTED MARINE PATENTS.

The publication in this column of a patent specification does not neccessarily imply editorial commendation.

817,227. ANTITORPEDO CONSTRUCTION FOR WAR VESSELS. WILLIAM A. DOBSON, PHILADELPHIA, PENNSYLVANIA.

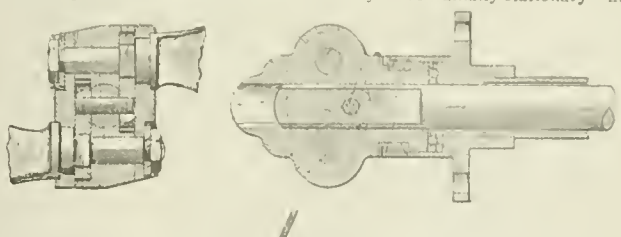
Claim.—2. In a device of the character described, a downwardly and inwardly extending armored bulkhead and an exterior hull forming, be-



tween it and the bulkhead, a path of less resistance to explosives than that of the bulkhead, the direction of which path is external to the main plane of the bulkhead. Thirteen claims.

817,728. REVERSIBLE PROPELLER-WHEEL. FRANK M. SPAULDING, ST. JOSEPH, MICH., ASSIGNOR TO WILLIAM H. HULL, ST. JOSEPH, MICH.

Claim.—3. The combination of a rotary but axially-stationary hub,



blades adjustably mounted on said hub, the stems of said blades being

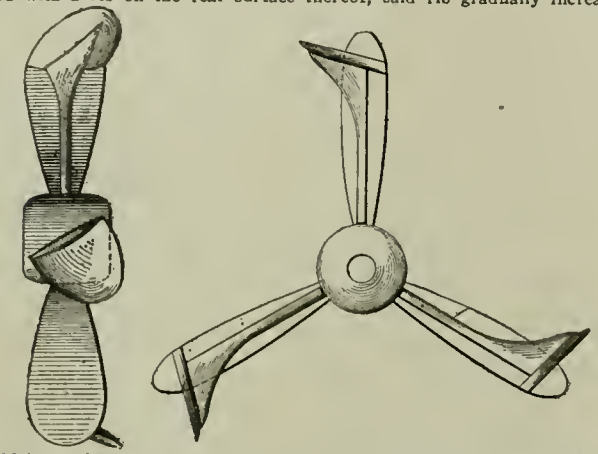
provided with crank-arms and each crank-arm having a longitudinally-extending slot; an endwise-adjustable shaft provided with a pin engaging and working in said slots and adapted to rotate said hub and slide longitudinally therein; a bearing in which said propeller-wheel shaft is mounted and which sustains the thrust of the propeller-wheel; an engine-shaft having a telescoping connection with the end of said propeller-wheel shaft; and manually-operated means for shifting said propeller-wheel shaft endwise for the purpose of reversing the said blades. Ten claims.

817,262. GOVERNOR FOR MARINE ENGINES. JAMES W. MOWBRAY, WALTON, CANADA.

Abstract.—The object of the invention is to devise a simple, cheap, positive, and effectual governor to prevent the engine racing due to the lifting of the propelling-wheel out of the water in high seas; and it consists, essentially, of a stand-pipe extending through the bottom of the boat in proximity to the stern, a cylindrical casing secured to the upper end thereof, a piston located in such casing and having a piston-rod connected thereto and extending through the upper end of the casing, a supplemental piston connected to the upper end of the piston-rod, a supplemental cylinder suitably supported above the main cylinder and in which the supplemental piston works, and a lever suitably pivoted at one end and connected to the piston-rod, and means connecting the free end of the lever with the butter-fly throttle-valve on the steam-pipe of the engine. Four claims.

817,494. PROPELLER-WHEEL. ALBERT HENRY LITTLE, NEW YORK.

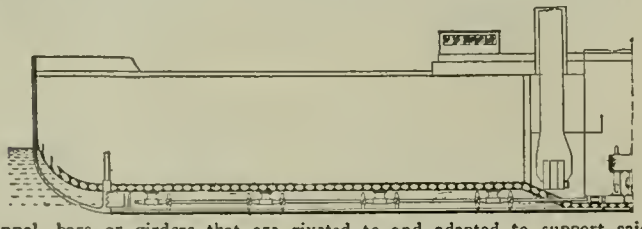
Claim.—3. A propeller-wheel having a series of blades, each being provided with a rib on the rear surface thereof, said rib gradually increasing



in thickness from the hub out, and a scoop resting on the end of said rib and near the end of the blade. Five claims.

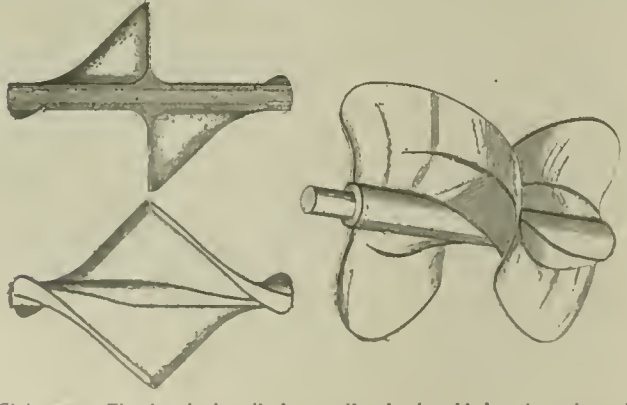
817,519. VESSEL PROPELLED BY STEAM. ERNEST C. ROBINSON, WEST HARTLEPOOL, ENGLAND.

Claim.—8. A navigable vessel comprising a tunnel that extends from end to end of the lower part of said vessel and is furnished with a bottom consisting of metal plates wherein throughout the entire length of the tunnel, openings are provided; extending throughout the entire length of said



tunnel, bars or girders that are riveted to and adapted to support said plates; at each end of said vessel a stem-post or frame that extends to the bottom of said tunnel and has formed in it an opening adjacent to the corresponding mouth of said tunnel; and rudders mounted within said openings in the frame or stem-post and inwardly turned toward the mid-ship section of said vessel. Ten claims.

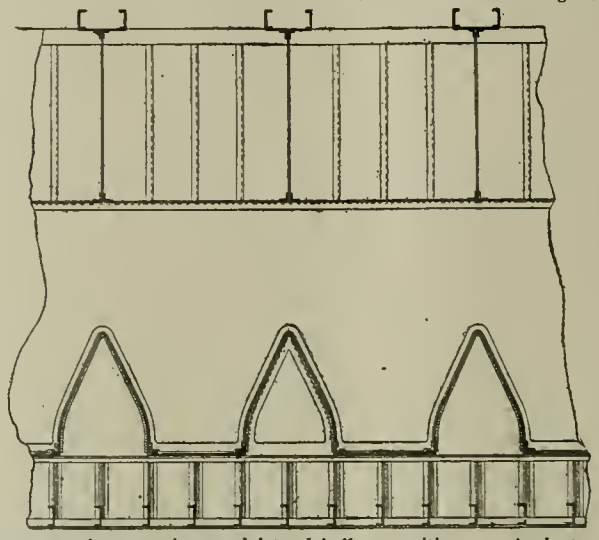
818,125. PROPELLER. ROBERT W. SHAW, STAMFORD, CONN., ASSIGNOR TO THE SHAW PROPULSION COMPANY, A CORPORATION OF NEW YORK.



Claim.—5. The herein-described propeller having blades throughout its length, said blades having curved flanges and being spirally disposed with substantially one half thereof (measured longitudinally) in an intersecting spiral plane relative to the body portion of the propeller whereby but one of said halves will act upon the water to propel a vessel when the propeller is positively driven, and the other half will act upon the water to propel a vessel when reversely driven. Seven claims.

818,259. SHIP CONSTRUCTION. JOSEPH KIDD, DULUTH, MINNESOTA.

Claim.—1. The combination of an inner and outer hull forming water-



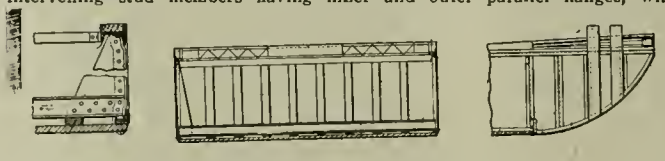
compartments between them and lateral hollow partitions on the bottom of the inner hull communicating with the water-compartments and forming a series of lateral hoppers for the bulk cargo. Four claims.

818,778. FIRE-BOAT. LEWIS NIXON, NEW YORK.

Claim.—3. In a fire-boat, the combination of a gas-engine, a pump, a clutch connection with said gas-engine, a centrally-located rigidly mounted main nozzle, and automatic means for throwing and distributing water from said pump to cool the decks. Four claims.

819,633. BARGE. ARTHUR M. BOWMAN, AVALON, PA.

Claim.—3. In a barge, the combination of sides composed of a skeleton girder-framework having upper and lower longitudinal flanged elements, intervening stud members having inner and outer parallel flanges, with



side plates secured thereon, cross-connecting bracing elements, and a floor composed of wood, sloping upwardly at each end and providing prow extremities, with supplemental prow-plates forming continuations of the bottom and curving upwardly at each end. Thirteen claims.

820,105. ELECTROLYTIC SHIP-BOTTOM CLEANER. GEORGE W. FRAZIER, ALLEGHENY, PENN., ASSIGNOR TO PITTSBURGH ELECTROLYTIC MANUFACTURING COMPANY, A CORPORATION OF PENNSYLVANIA.

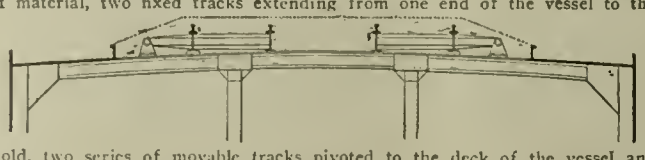
Claim.—1. In an electrolytic ship-bottom cleaner, the combination of a conducting-plate, tackle constructed to suspend said plate from the vessel movably contiguous to the side of the vessel below the water-line, insulating-fenders arranged to prevent contact between said plate and the sheathing or hull of the vessel, a conductor leading aboard from said plate, a source of electricity having one pole connected with said conductor and the remaining pole connected with the sheathing of the vessel. Six claims.

820,974. STEEL BARGE. MEIER G. HILPERT, PITTSBURG, PA.

Abstract.—The invention consists, generally stated, in constructing the barge of a number of separate sections or compartments, each of which preferably is a self-contained unit both as to stability and flotation, and which sections are constructed to be attached one to another, so as to build up the complete barge or fleet, which are constructed of sizes so that when empty a plurality thereof can be nested together, thus reducing the cubical contents and wetted surface and both expediting and rendering more cheap the return of the empty barges, which are of such a size that they can be lifted by suitable hoisting apparatus and unloaded by merely dumping the same, thus greatly expediting and cheapening the unloading thereof, which are of such a size that they can be transported by land as well as by water either on ordinary flat-cars, by telpherage system, or as desired, and which possess many other special features of construction and advantages, as will be hereinafter described and claimed. Fifty claims.

821,514. VESSEL. ALEXANDER LESLIE, WALKERVILLE, CANADA, ASSIGNOR OF ONE HALF TO GEORGE E. TITCOMB, PHILADELPHIA, PA.

Claim.—4. The combination of a vessel having a hold for the storage of material, two fixed tracks extending from one end of the vessel to the



hold, two series of movable tracks pivoted to the deck of the vessel and arranged to either swing over the hold and in alinement with the fixed tracks or to be thrown back clear of hold and out of alinement with the fixed tracks. Five claims.

International Marine Engineering

SEPTEMBER, 1906.

NEW ATLANTIC LINER EMPRESS OF IRELAND.

BY ALLAN McPHERSON.

The new twin screw steamer *Empress of Ireland*, built by the Fairfield Shipbuilding & Engineering Company, Limited, Glasgow, for the Canadian Pacific Railway Company, has carried out most successful trials on the Firth of Clyde, and the highly satisfactory speed of 20 knots has been attained. The tests included progressive runs over the measured mile at Skelmorlie, which were followed by twelve hours full speed and twelve hours coal consumption trials, the whole of the trials being carried out without stoppage.

The keel of the *Empress of Ireland* was laid in May, 1905, so that only eight months were required to bring her to the launching stage, in January, 1906. This vessel is the greatest launching weight ever put into the water by the Fairfield Company.

THE CANADIAN PACIFIC STEAMSHIP EMPRESS OF IRELAND, AT SEA.

The ship is of the following dimensions:

Length over all	570 feet 0 inches
Breadth molded	65 feet 6 inches
Depth to upper deck	40 feet 0 inches
Draught, loaded	28 feet 0 inches
Displacement in tons	20,000
Indicated horsepower	18,000
Gross tonnage	14,500

The keel is 3 inches in thickness, and there is a double bottom for water ballast to bring the ship to a draught that will obviate rolling or pitching. The total capacity for water ballast is 3,490 tons. Very deep bilge keels have been fitted for one half the length of the ship, and there are nine watertight bulkheads across the vessel from keel to upper deck, and so arranged that should any two compartments be filled with water the ship would remain afloat.

The ship, which is a sister of the *Empress of Britain*, described at page 16 in our issue for January, 1906, is built to Lloyds 3 deck and shelter deck 100 A 1 class, and has eight decks. The decks are named in the following order from above: boat deck, upper promenade, lower promenade, shelter, upper, main, lower, and orlop deck. All the decks are plated and covered with teak where exposed, and with yellow pine where not exposed to the weather. She has two pole masts, fore and aft rigged, with derricks, spars and other appliances for dealing with cargo.

The passenger accommodation has been admirably arranged. There is provision for 310 first class passengers, 500 second, 500 third, and 270 steerage, a total of 1,580. The lower and upper promenade decks are entirely devoted to first saloon passengers. The state rooms are fitted up in a most luxurious manner, and the walls and ceilings of each pair have been treated differently, some being hung with tapestry, and others panelled in satinwood, etc., with upholstery to match. The rooms are well lighted, and the passenger can, at will, have a light at almost any place convenient to himself. The bath rooms and toilet arrangement in the ship have received special attention, and are distributed throughout in the most convenient positions.

Commencing with the upper promenade deck, amidships is the first saloon entrance. It has a handsome staircase leading to the lower promenade deck, and from there to the shelter deck. The staircase is panelled in dark colored polished teak, and is lighted by a large dome above, with leaded glass panels. Aft, and within easy access of the entrance on upper promenade deck, is the music room, which is treated in a light and airy style. The walls are exquisitely panelled in satinwood, and broken by pilasters richly carved and fluted. The ceiling is finished in white

THE CAPTAIN'S BRIDGE VIEWED FROM FORWARD.

and gold, and the room is flooded with soft light from the artistic dome above, with its tastefully designed leaded glass panels. The grand piano and the furniture of the room are carried out in satinwood. The rich carpet is of a soft green shade, and the settees and easy chairs are upholstered in velvet of the same color. A charmingly designed mantelpiece, with artistic brass sides and canopy, adds to the appearance of the room. The deep oriel bays at each side, with their inviting

THE FIRST CABIN SMOKING ROOM.

settees and cosy corners, all tend to suggest that the passenger is in a modern hotel, rather than voyaging across the Atlantic.

The café, which is one of the latest features in up to date ships, is situated on the lower promenade deck, immediately below the music room. The paneling is framed in Italian walnut with tapestry panels, and the settees and chairs are upholstered in a pleasing shade of green velvet. The floor is laid with interlocking rubber tiles, green and white. In the center of the room is the well over the first class dining saloon.

Forward of the café, on the same deck, is the library. This is a very comfortable apartment, framed in rich mahogany, with Amboyna panels, and there is a large book case and other furniture to match. The settees and easy chairs are upholstered in green velvet, and the floor is laid with a rich carpet.

Aft of the café is the first cabin smoke room, which is large and commodious, and well lighted, having large square windows around the sides and a rectangular well above, with ornamental fretwork and provision for ventilation. The walls are framed in oak with hammered brass panels. The settees and chairs are upholstered in brown leather, and the floor is laid with interlocking rubber tiles, brown and white.

On each side of the lower promenade and upper promenade decks amidships is a clear promenade of 10 feet 6 inches for the first saloon passengers. The lower promenade deck extends right aft to the stern of the ship. This is a feature introduced for the first time into ships of this class, and forms a splendid open promenade.

On the deck below, which is the shelter deck, leading from the main staircase there is the first class dining saloon. This room is situated forward of amidships, extends the full width of the vessel, and is 58 feet long. The full complement of saloon passengers will be able to dine at once. In the center of the saloon are four large dining tables running fore and aft, and at the

THE FIRST CLASS DINING SALOON, WITH SIDE ALCOVES.

ship's side in alcoves there is an entirely new arrangement of dining tables, each table being of the horseshoe shape, and seated for five persons, the five seats form a semicircle around the tables being of the latest tip-up opera house style.

In each alcove along the ship's side are two large windows with ornamental shutters, which, together with a large oval dome overhead in the center, afford splendid light to the saloon. The paneling is in mahogany, enameled white above, with carving in old gold; the ceiling also is in white and gold. The furniture is upholstered in light crimson leather, harmonizing with the Turkish carpet runners on the floor. At the fore end is a piano, and at after end a large sideboard.

Aft of the first class dining saloon are the pantries, with the various galleys, bake house, bakers' shop, confectionery, etc., forming one large kitchen, equipped with the best cooking apparatus that can be devised. Among other devices arranged in the galleys are machines for making sandwiches, for cutting bacon, for boiling eggs, and also for washing dishes.

Forward of the first class dining saloon, is a separate dining saloon for children. The room is tastefully arranged with pictures around the walls. The tables are fitted with revolving chairs, and the upholstery is in crimson leather.

The second class apartments are on the shelter deck,, and are hardly inferior to those provided for first class passengers. Indeed, the saloons and state rooms on this ship are an improvement on the first class accommodation on many vessels at present crossing the Atlantic.

The second cabin dining saloon will seat about 300 persons, and is fitted with alcoves at the sides, after the style of the first saloon. The walls are paneled in light mahogany, with furniture to match. This room also extends the entire width of the ship. Through double swinging doors at the after end the social hall is reached. The walls of this room are framed in light oak, with light oak panels below, and bird's-eye maple panels above.

Leaving the social hall and crossing the shelter deck, which is entirely sheltered by the lower promenade deck, a passenger comes to the second cabin smoke room. This room, like the first class smoke room, is arranged with cosy corners, arm chairs and small tables.

Leaving the shelter deck by one of the many stairways the upper deck is reached. This deck has two side passages fore and aft; the one on port side is divided off for use of the ship's company, and working the ship generally, while that on the starboard side is arranged for the accommodation of first and second class passengers. A nursery fitted up in simple style is provided for the use of children.

Below the upper deck is the main deck, where the majority of the second class state rooms are situated. These are comfortable rooms sleeping two, three or four persons, and fitted up somewhat similar to first class state rooms.

THE STERN OF EMPRESS OF IRELAND BEFORE LAUNCHING, SHOWING PROPELLERS.

On the main deck forward, the third class passengers are berthed in cabins accommodating from two to six passengers. There is a large dining saloon for third class, capable of dining 300 persons. The tables are fitted with revolving chairs, and a piano and sideboard, etc., are provided. From stairways in each compartment passengers can reach the promenade on the upper deck, which is covered, or the open promenade on shelter deck.

On the upper deck forward is the third class smoke room and third class ladies' room, both of which are fitted in a most comfortable manner; also a play ground is provided for children. On the main deck forward and on the lower deck provision is made for steerage passengers in open berths, with ample dining

THE MUSIC ROOM, ON UPPER PROMENADE DECK.

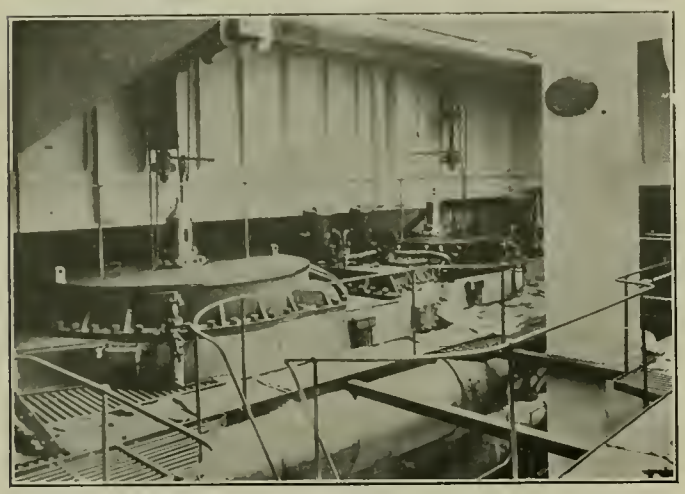
THE LIBRARY AND WRITING ROOM.

accommodations and all conveniences which tend to their comfort.

There are also arranged at suitable parts of the ship a hospital, dispensary, printing room, hairdressers' shop, mail room and specie room. Wireless telegraphy is arranged for, and a suitable house is fitted out on upper promenade deck for the receipt and dispatch of messages.

Part of the lower deck and all of the orlop deck is cargo space, and two of the 'tween deck holds are insulated for carrying frozen meat.

Special consideration has been given to the ventilation of the ship, and the thermotank system has been adopted as the most efficient. There are eighteen thermo tanks, suitably placed, to supply either heated or cold air, or to extract foul air from any part of the ship. In addition to the thermotank system, electric fans have been fitted in the public rooms and galleys. There is a complete installation of electric light, with generating plant consisting of three independent engines and dynamos, providing power for a liberal number of lights in all compartments, especially the public rooms.



THE UPPER PORTION OF THE ENGINE ROOM.

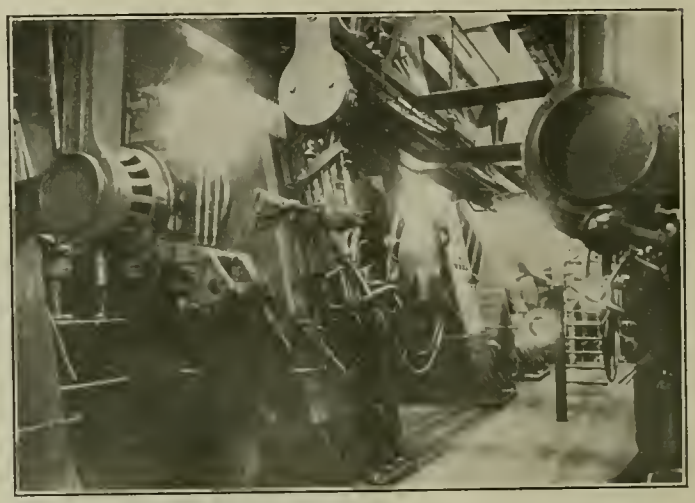
There are twelve cargo winches and two boat hoists, the driving gear of the winches being so arranged that no noise is created while working.

The propelling machinery consists of two sets of quadruple expansion engines, each set having 4 cranks, balanced on the Yarrow, Schlick, Tweedy system, and each engine, running at 80 revolutions, indicates over 9,000 horsepower. The cylinders are 29, 48, 63 and 96 inches in diameter, the stroke in all cases being 54 inches. The two propellers are 19 feet in diameter and have each four blades of manganese bronze. The crank shafts, the thrust, tunnel and propeller shafts are of forged mild steel.

All the auxiliaries are separately driven, including the air pumps. There are for each engine two condensers, each with separate pumps, and thus the liability of complete breakdown is greatly reduced. The condensing water is circulated through the condensers by two centrifugal pumps. The engine room is fitted with all modern appliances, including two evaporators, working in combination with two distillers for supplying fresh water to the ship and boilers.

There are six double and three single ended boilers of the ordinary multitubular type, adapted for a working pressure of 220 pounds per square inch. These are placed in two boiler-rooms, with a large coal bunker between. The double ended boilers have each eight furnaces, and the single ended, four furnaces. These give a total grate surface of 930 square feet, and a heating surface of 42,600 square feet (ratio 45.8 to 1), and are arranged to work with Howden's forced draught.

The engines during all the trials worked most satisfactorily, alike in respect to power and economy, and on four runs at full power the mean of mean speeds was a fractional point over 20 knots. The speed guaranteed in the contract was 19¼ knots, and



STARTING PLATFORM, ENGINE ROOM OF EMPRESS OF IRELAND.

the vessel was required to carry on a mean draught of 27 feet 6 inches, a cargo of 6,500 tons, in addition to the coal and stores required for the transatlantic trip.

ON PIPING AND POWERING OF SHIPS.

BY G. E. SMITH.

In the subject of ship design the arrangement of the auxiliary machinery in the ship is usually left, except in a very general way, until the structural work has progressed so far as to make much changing out of the question. This is a great oversight. By a careful study of the conditions in the vessel under consideration, the auxiliaries can be located so as to reduce the amount, and increase the efficiency, of piping and connections, very materially. The modern method of shop design is to arrange machinery, etc., in general, so as to start the raw material in at one end and turn out the finished product at the other. This same ruling should apply as far as possible to the machinery of a ship. The steam, starting at the boiler, should go direct to the engines, the latter preferably designed with the high pressure cylinder nearest the boiler room. (The location of the cylinders in the engine is of course a matter which depends largely on the design of the engine itself).

The main condenser should ordinarily be aft, in a vessel fitted with screw propellers, with the circulating pump and connections at its after end. The channel way from condenser should lead forward to the main air pump, the discharge from the air pump leading forward to the main feed tank. The suction from main feed tank should carry out the same idea, and lead forward to the main feed pumps located at forward end of the engine room; from here the feed lines, leading forward, still, go to boilers. In this way pipes do not return on each other, and we have a complete loop from and to the boilers.

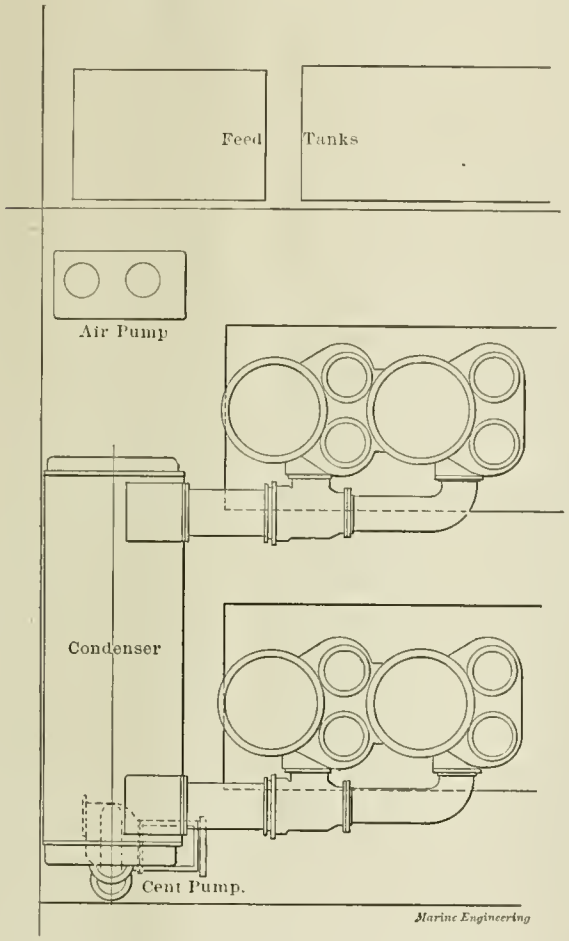
The above remarks of course apply in a general way only, as modifications are frequently necessary owing to a saving in one direction offsetting one in another. By placing a pocket in a bunker or cargo space for small machinery, we frequently can gain much valuable passage room. Great care should be exercised in locating the machinery to insure the "get-atableness" of all parts. See that all condenser tubes can be readily removed without taking down parts of the other machinery or piping.

All valves must be in easy reach for operation or repair, bilge boxes and manifolds where they can be readily cleaned; oil boxes and tanks where the men can properly attend to them. Pumps,

blowers and other auxiliary machinery must be located so that piston rods, valves, etc., can be easily reached for repairs, and so that the machinery can be taken apart without interfering with the neighboring pipes and fittings.

An outline sketch of ladders and gratings should be gotten out before any machinery is permanently located, and especial care given to clear passages and location of ladders, to give easy access to and exit from boiler and engine rooms.

Other points, usually left until later, which should be carefully planned out in the early stages are, the hoisting gear for cylinder and condenser heads and the location of counters, gages and telegraphs. If possible the counters, clocks and gages should



ARRANGEMENT FOR ONE CONDENSER WITH TWIN SCREWS.

be located on one gage board in view of and near the working platform, and the log desk should be placed close by.

In fast twin screw ships of small type, where there is not an abundance of spare width, a most satisfactory solution, where the length of the engine room is available, is to use one condenser placed athwartship near the after engine room bulkhead, and connect both engines to it, with circulating pump and dynamos on one side, and air pump and tanks on the other. The condenser is something which rarely gives trouble if properly designed and installed, therefore the objection which is raised regarding one condenser for two engines, that in case of accident to the condenser both engines are out of service, is hardly a valid one. In a single screw ship but one condenser is used, and a stoppage due to condenser troubles is most rare.

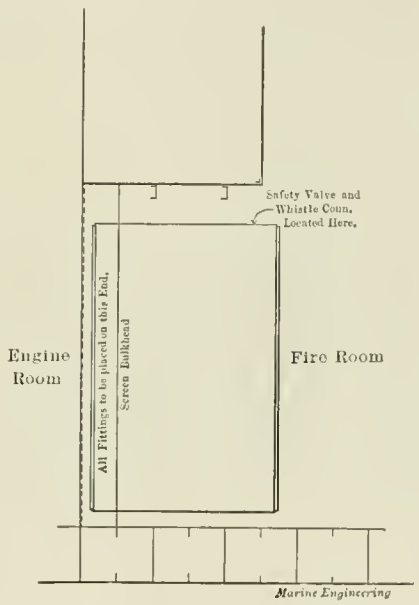
A single feed and filter tank is also frequently a space saver. By installing one tank with discharge from both air pumps on one side of the ship, the corresponding space on the other is available for evaporators, dynamos, or for whatever else it may be needed.

The blowers should also be sketched in position, together with the duct to the air boxes, if the Howden system is used. In locating the blowers care should be taken to keep the engines entirely out of the boiler room, or at least in a space easily ventilated and which can be kept at a livable temperature. Where the engines are kept entirely outside of the boiler room all trouble from coal dust in the bearings is eliminated and the heat is reduced. A good arrangement is to have the engines in a compartment open to the engine room, and the blowers in the boiler rooms connected by properly supported shafting to the engines.

The ash hoists, railways, ejectors and ventilators should be lined in and carefully designed at the start. By getting all these arrangements under way and advancing them far enough to see just what difficulties must be met, each part can give a little to the other, and the result is a well balanced whole, instead of half the work having an undesigned appearance.

Before the run of main steam is decided, the smoke boxes, uptakes and smoke pipe should be sketched in with care as to the areas at the various points, and the upward lead should be always at least 30 degrees to the horizontal.

The constructor, in order to increase to the greatest possible degree the cargo carrying capacity, is prone to cut down the size of the boiler hatch below proper limits. In many cases when the expert is called in by ship owners to tell why his ship



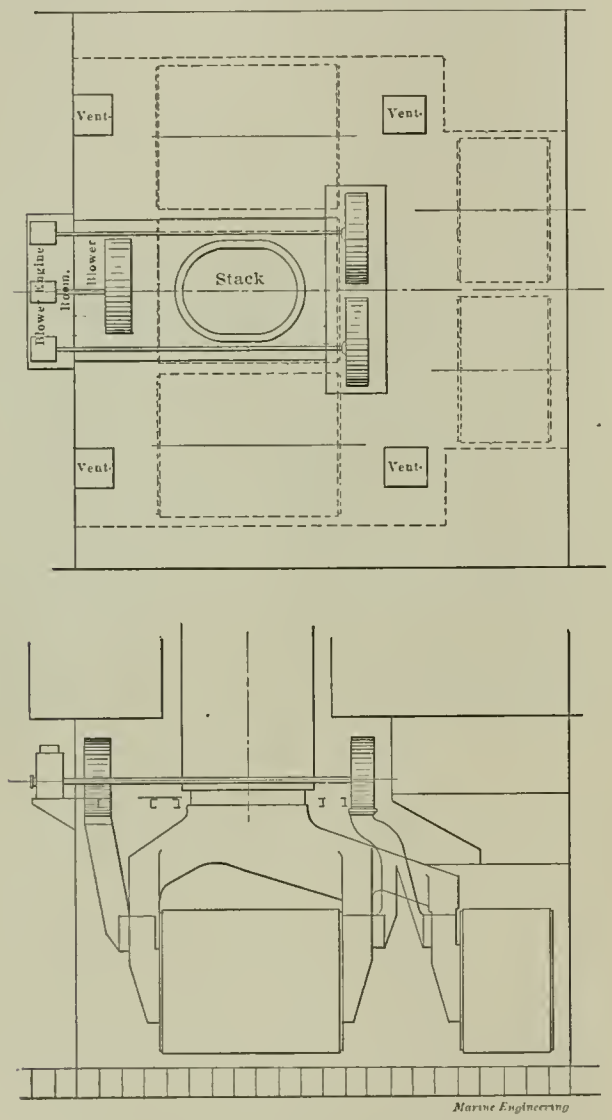
TRAMP TYPE OF FREIGHT STEAMER.

costs so much to run, the trouble is apparent as soon as the engineer looks inside the hatch. The hatch is so small that the leads from the boilers to the stack are flat, and frequently circuitous, and the result is poor draft conditions. On one job the writer has in mind the leads were perfectly horizontal, the areas low, and even under these conditions the clearance between the coaming and the uptake was but one quarter inch. Imagine the cost of templet and fitting of this plate work. This was paid for twice, as in overhauling, new boilers were installed, and new uptakes and stacks, and as the ship work was not altered the plant had to be duplicated. Properly designed hatches and uptakes would have saved the builder on his original cost, and the owner on his coal bills, to a degree probably considerably in excess of the returns from cargo stowage.

The owner is not impressed by the large horsepower furnished by the engine, or the horsepower per pound of fuel consumed; such points are interesting to the engineer only. What the owner wants is small operating expenses with large freight returns, and to get this the machinery plant must be economical,

and the lines of the ship such as to bring the largest carrying capacity with the least amount of propulsive power. Model experiment helps to solve the problem of least propulsive coefficient. If owners would take up the matter with the expert in the preliminary stages, stating the conditions under which his ships are to be run, as to speed, average cargo, stowage of cargo, etc., he could get advice as to the best compromise which will give the largest return on money invested. The cheapest boat is not necessarily the most economical, and the large, high priced ship not always a money saver. The contractor is frequently not in a position to give unbiased judgment.

Economy of ships is a subject most complex in some ways



SKETCH SHOWING ARRANGEMENT FOR BLOWERS.

and yet is a most interesting and profitable one to the ship owner as well as to the naval architect and engineer.

In Germany the subject is being studied, and, while great economy has not been reached, the tests, on the larger ships at least, have proved the correctness of the preliminary calculations, while in the majority of cases in this country the resulting horsepower, coal comsumption, etc., have been quite different from expectations. Sometimes the economy has been greater, but in most cases much less, than contemplated. The reason for this usually is that the calculations have not been taken up in a sufficiently detailed manner to take account of clearance spaces, cylinder ratios, steam drop, friction of parts and other points. Sometimes the type of engine is not adapted for the particular service required.

It is to be hoped that the whole subject will receive greater attention from ship owners in the future than in the past, and that eventually the economy of the stationary service will be reached.

In taking up the piping arrangement the first thing planned out should be the main steam pipe. Great care should be exercised in this work to be sure that the best possible solution is found. The run should be as flexible as may be, yet have few bends and fewer expansion joints. Cut out the latter wherever possible, as they are invariably a source of trouble and annoyance.

With the foregoing properly blocked out, the detail of the design may be taken up with the assurance of first class results. Above all keep in mind that the less the amount of piping and fewer the valves and fittings used, provided all necessary connections can be made, the more efficient the system. This has the additional advantage of less joints to keep tight, less original cost, more satisfaction to engineer and owner, and this is the ideal arrangement.

For a small cargo ship where two single ended boilers are used, the ideal solution is the English tramp type modified. That is, back the boilers into the engine room, and place a screen bulkhead about 18 inches forward of the back head of the boiler. On the back of the boiler and the 18-inch exposed space all the fittings, including the gage glass, can be located, and every valve, except the whistle and safety valve, is under the direct care of the engineer. This arrangement gives greater cargo capacity, reduced operating crew, and keeps the engineer in close touch with everything.

This in a general way covers preliminary design.

Taking up the design in detail, the boiler naturally comes first. The scantlings of the boiler are so almost entirely governed by the rules of the Steamboat Inspectors and of the various insurance societies that their discussion does not belong here. A few points may be worthy of notice, however. Referring to the Scotch boiler (this being the usual type designed by shipbuilders, the water tube being furnished complete by subcontractors) be sure that ample steam space is provided above the tubes. About one-third the diameter of the boiler is a good height to leave for this purpose. Locate manholes and handholes so that every part of the boiler can be reached for cleaning. Design the furnaces so that they can be readily and cheaply removed in case of collapse. Provide separate and distinct stop valve and internal pipe systems for the main and the auxiliary feed connections. Frequently a boiler is entirely thrown out of service by accident to one or the other, where a single connection is used for both. In locating single ended boilers in the ship, provide ample room (say 20 to 24 inches in the clear) between the boiler and the bulkhead, so the workmen can get at the stays and calking edges to properly repair them when necessary. Provide internal dry pipes for both auxiliary and main steam connections, where they have separate attachment to the boiler.

In the design of the uptakes, easy upward leads with areas not less than one-fifth of the grate where forced draft is used, and one-sixth for natural draft, will be found advantageous from the economical standpoint.

In arranging the piping systems in the boiler room, locate only absolutely necessary valves there; wherever possible put the connections in the engine room. The leads in the boiler room should be short and direct, with valves close to or in the passages, where they can be seen and reached by the water tender in his regular tour of duty. The more easily the valves and connections can be examined the better care will be taken of them by the men. In the main and auxiliary feed and boiler blow and pumping out systems the valves on the boilers should be the only ones in the boiler room, and in the tramp type already referred to, not even these. Pressure lines of all kinds should be above the floor and kept out of the bunkers. Run

pipes between boiler rooms and engine rooms in passages, where possible; it is not especially conducive to good temper to find it necessary to trim many tons of coal in the bunkers in order to get at a leaking joint box inside. Engineers should insist on this point being kept in mind by designers.

In ventilating the boiler rooms, care must be taken that at least all points which must be visited by the men are carefully ventilated. Donkey boiler and blower spaces should be most carefully looked into in this matter.

The whistle pipe should have direct connection to at least two of the boilers at the forward end of the boiler room, and likewise be connected to the auxiliary steam line. The leads of these pipes should be as nearly vertical as possible, so that no accumulation of water can take place, all being drained direct to the boilers.

Where there are two stacks, a single escape pipe, carried up the forward side of the after stack, is frequently the best arrangement. The area of this pipe should be about 60 percent of the combined area of the outlets from all the boiler safety valves connected to it.

Vertical ladders from the firerooms are usually the best, as they take up less room and firemen in many ways prefer them. Ladders, where angled, should be about 30 degrees from the vertical, in boiler or engine rooms. Be sure that every valve can be reached from the floor or grating. With these general hints, we will leave the boiler room and proceed to discuss the engine room in detail. As this is not a treatise on steam engineering, only odds and ends of design, where faults are likely to creep in, are mentioned.

We will assume that the main engine has been located with due care as to proper passages around it, and as to location of foundation bolts in ship floors. In designing the engines, clearances are unfortunately given small consideration. In engines designed a few years back, and still being built from the old patterns, clearances at times amount to 30 or 40 percent. This entails a large waste of energy, and results in reduced economy. Now the ship owner is looking to his pocket book and if he obtains a ship which is especially economical in the matter of coal and supplies, he will endeavor to duplicate it at the earliest opportunity. Therefore it pays to redesign, and most carefully, all plans of engines to be built, and see if the economies of land practice cannot be duplicated. The reciprocating parts should be balanced as far as possible by proper weight of pistons. This is important in small engines, though in large ones not so much so, owing to other conditions arising, of greater importance.

The use of manifold valve boxes, instead of a series of valves in pipe lines, is a space saver, and makes a much handier arrangement for the engineer, besides reducing the number of flange joints to be cared for. This especially refers to the suction and discharge from feed and donkey pumps, although in some cases, as in dynamo rooms and similar arrangements where a group of machines is located, it is also advantageous for steam.

In the design of the condenser, baffle plates, carefully located to give the best distribution of the exhaust steam, will greatly improve the vacuum conditions and resulting economy. The condenser should be allowed ample cooling surface. Economy in the size of the condenser does not improve the economy of operation. An allowance of 1.3 square feet for triple, and 1.4 to 1.5 square feet for compound engines per horsepower will give good results. The circulating pump should have a short, straight connection to the sea and be located if possible, under the condenser, discharging by a short, straight lead directly into the water head.

While these hints are theoretically correct, so many conditions arise to alter them that no general rules can ever apply. More care and interest should be taken in the detail parts of a machinery and pipe arrangement by the chief draftsman and his assistants. The whole is usually left to the draftsman in charge, with the result that many small points are slighted. Inspectors and engineers, representing the owners of ships building, should most carefully study the proposed arrangement, so that changes for the better can be made on the drawings, instead of waiting until things are installed, when the expense of change is prohibitory.

THE ENGLISH SCOUT CRUISER ATTENTIVE.

We present herewith a photograph of one of the latest cruisers of this type, there having been constructed for the English navy in the last three years not less than eight of these vessels, which are almost duplicates in design, speed and power. The *Attentive* is a sister ship of the *Adventure,* both of which were built by Sir W. G. Armstrong, Whitworth & Company, Limited, at Elswick. The displacement is 2,750 tons; length, 370 feet between perpendiculars; beam, 38 feet, and normal draft, 13 feet 3 inches. The twin screw engines are of 17,000

THE ENGLISH SCOUT CRUISER ATTENTIVE.
(Copyright, 1906, Cribb, Southsea.)

indicated horsepower, and are supplied with steam by Yarrow boilers, the designed sea speed being 25 knots. This was somewhat exceeded on trial.

The *Attentive* carries a battery including ten 12-pounders and eight 1-pounders, the main purpose of which is for use against hostile torpedo destroyers and torpedo boats which might attempt to interfere with her keeping in touch for scouting purposes with the enemy's fleet. In addition to the guns, the vessel carries two 18-inch Whitehead torpedo tubes, with torpedoes of a maximum range of four thousand yards.

It will be noted in the photograph that the bow is given a very considerable flare, for the purpose of throwing off waves which might otherwise have a tendency to climb on board; this should keep the ship fairly dry, and add much to the comfort of those on board. The complement consists of 268 officers and men. The cost of the vessel complete is understood to have been about £275,000 ($1,350,000). No armor is carried except a deck 2 inches thick on the slopes and 5/8-inch on the flat.

It is reported, and denied, that the Hamburg-American Line has given a contract to Harland and Wolff, of Belfast, for a ship larger than the Cunarder *Lusitania.* One report is that the ship is also to be faster than the English flyer.

LA PROVENCE.

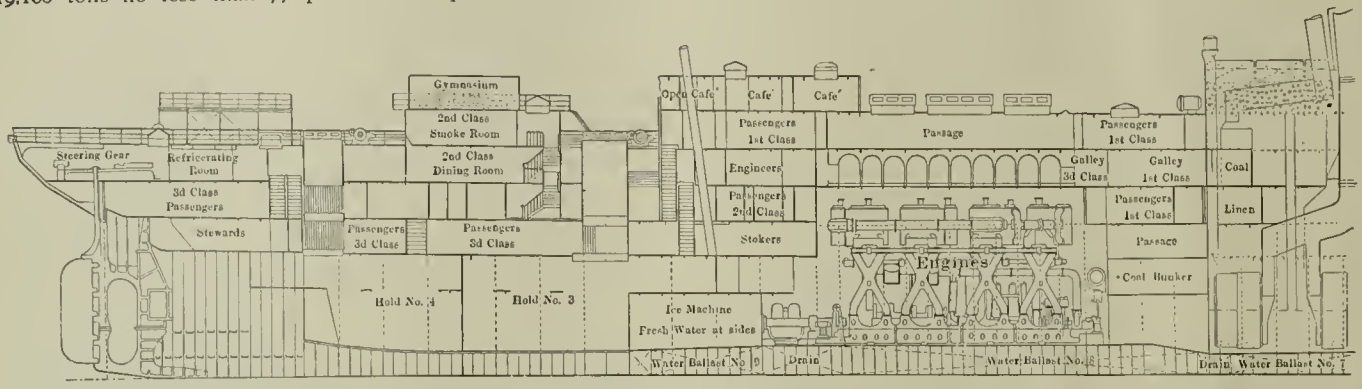
We have already given this ship a fairly comprehensive description,* hence will confine the present information to that not previously covered.

It is interesting to notice that out of the total displacement of 19,160 tons no less than 77 percent is required for the fixed weights of hull, machinery, equipment, fittings, etc., leaving only 23 percent, or about 4,400 tons, for the movable weights. Of this latter amount, some 3,500 tons comprises the necessary coal supply for the voyage, while the remaining 900 tons only is available for cargo, provisions, stores and passengers, this being 4.7 percent of the displacement. The capacity of the holds for merchandise is 2,320 cubic meters. In addition to this, there is a capacity for 1,655 cubic meters of merchandise or cargo in the compartments devoted otherwise to steerage passengers.

All of the hull is of Siemens-Martin steel, but while the bottom is of soft steel with a tensile strength of 44 to 50 kilograms per square millimeter (28 to 32 tons per square inch), the upper parts are of semi-hard steel with a strength of 55 to 62 kilograms per square millimeter (35 to 39 tons per square inch). It has thus been possible, without necessarily going to the extreme limit of these figures, to diminish the weight of scantlings, and obtain a saving of about 350 tons in the weight of the hull. Compared with the total displacement, this is an insignificant figure, but when it is compared with the amount of weight available for passengers, etc., it is seen that it constitutes nearly 40 percent of that total.

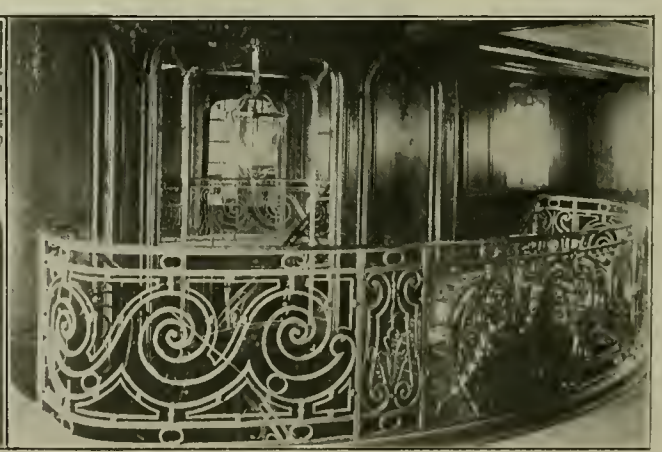
The central portion of the ship is provided with two bilge keels. The double bottom, divided into a number of independent water tight compartments, covers almost the entire length of the ship, and serves not only to give security in case of leakage, but also to contain water ballast. The ship is divided along the length into twenty-two compartments by twenty-one transverse water tight bulkheads. These bulkheads are pierced by sixteen water tight doors operating by hydraulic power and by hand, and designed on the Stone-Lloyd system. This system of hydraulic maneuvering permits under ordinary circumstances a separate opening or closing of each door by the operation of a handle placed opposite the door. In case of danger or for the exercises which take place every twenty-four hours, the captain may from his bridge close all the water tight doors in the ship. He may in making the reverse maneuver reopen all those to which the manipulator was previously set at the "open" position. A loud bell always precedes this closing from the bridge. If, in spite of this notice, any one is locked into a compartment, he may, by operating the proper handle, open the door, which closes again after his escape. The water necessary for operating the doors is maintained in two accumulators under a pressure of 36 kilograms per square centimeter (510 pounds per square inch). It is kept at this pressure by a Weir pump, which is always in operation when the pressure is below the predetermined figure.

The main engines are two in number, each of 15,000 horsepower, and are supplied with steam by twenty-one boilers. The lightening of the boilers is due to the use of semi-hard steel. The boilers employ forced draft by means of hot air blown into the ash pit. For the engines there has been adopted a rapid rotation, while materials of a considerable strength have been used for the moving parts and certain of the fixed portions. Nickel steel is used to some extent in place of soft steel for the shafts, and cast steel in place of cast iron for the bedplates of the engine. The twenty-one boilers are of the cylindrical marine type with return tubes, and are all single-ended, with four furnaces. They are distributed in four fire rooms, of which three



LONGITUDINAL SECTION OF FRENCH LINE STEAMSHIP LA PROVENCE.

THE FIRST CABIN SMOKING ROOM.

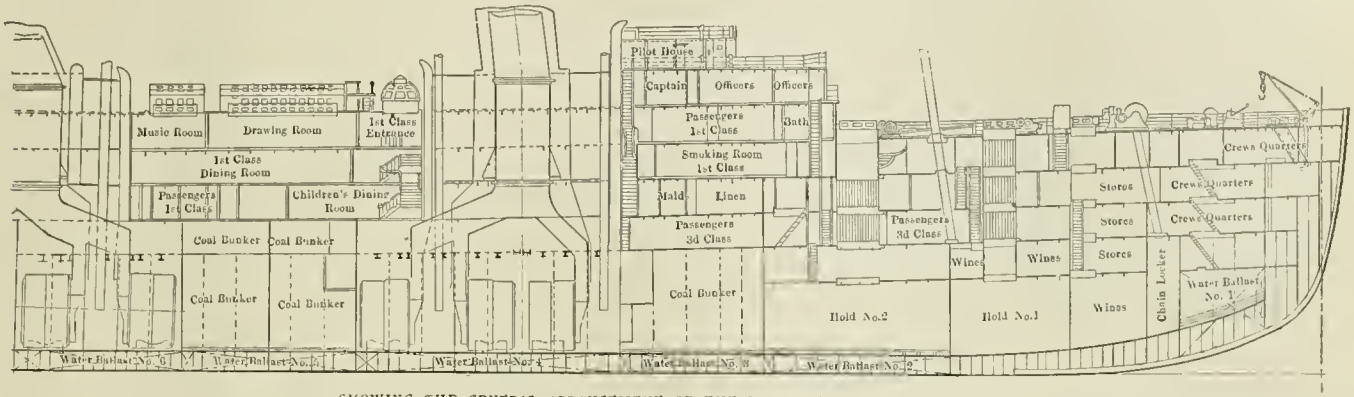


ORNAMENTAL RAILING, FIRST CABIN ENTRANCE.

*Pages 206, May, 1905; 315, August, 1905; and 221, June, 1906.

contain each six boilers, and the foremost fire room three only. A single funnel serves in each case two groups. These funnels are elliptical in section with a major axis of 4.71 meters (15 feet 5 inches) and a minor axis of 3.92 meters (12 feet 10 inches,) while the height above the grates is 30 meters (98 feet

The boilers operate with forced draft by means of air blown into the ash pits, which are hermetically closed, while a certain proportion is led in above the fire. This system has the advantage of leaving the fire room in direct communication with free air, instead of necessitating its being sealed. In this way

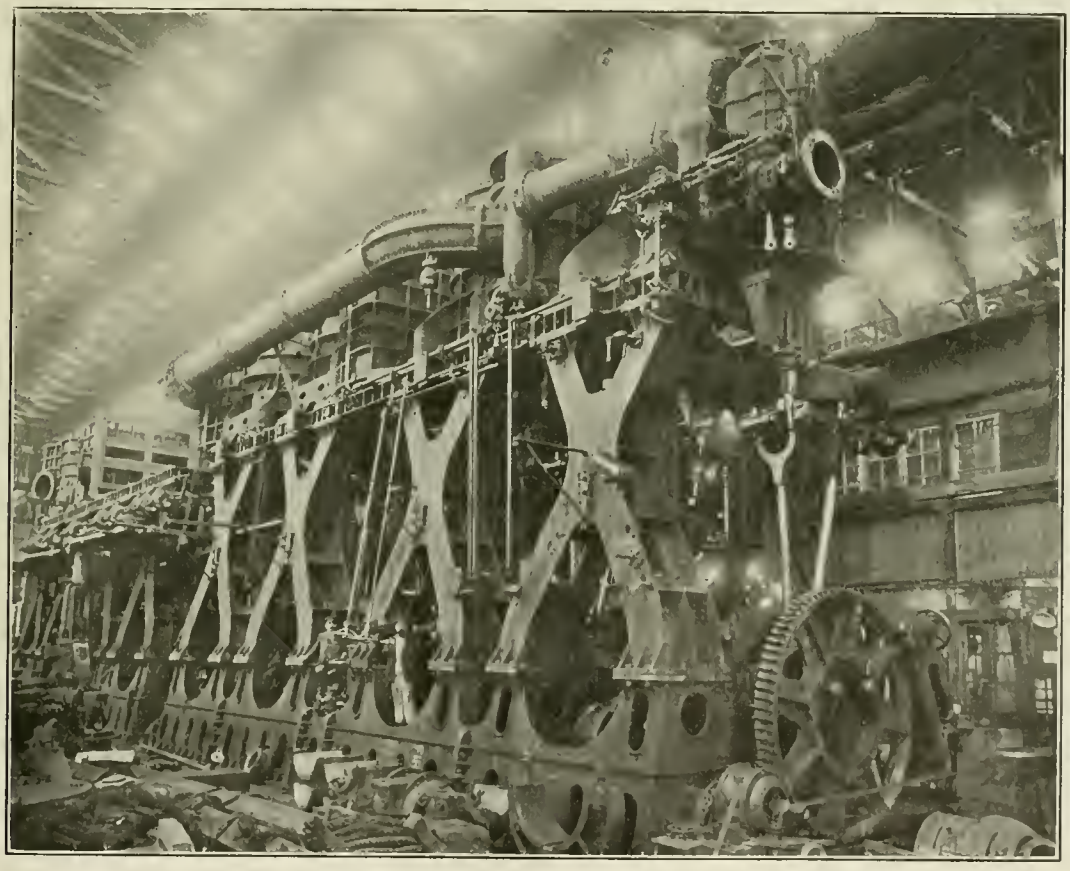


SHOWING THE GENERAL ARRANGEMENT OF THE MACHINERY AND ACCOMMODATIONS.

5 inches). The length of the boilers is 3.3 meters (10 feet 10 inches), and the diameter 5.2 meters (17 feet) for the after boilers, while the diameter of the forward boilers is 4.9 meters (16 feet). The furnaces are of the Deighton corrugated type, the total grate surface being 146 square meters (1,570 square

the designers avoided submitting the stokers to a largely increased temperature.

The air necessary for combustion is furnished by fourteen ventilators, two for each three boilers. These ventilators draw the air from out-of-doors and discharge it into special com-



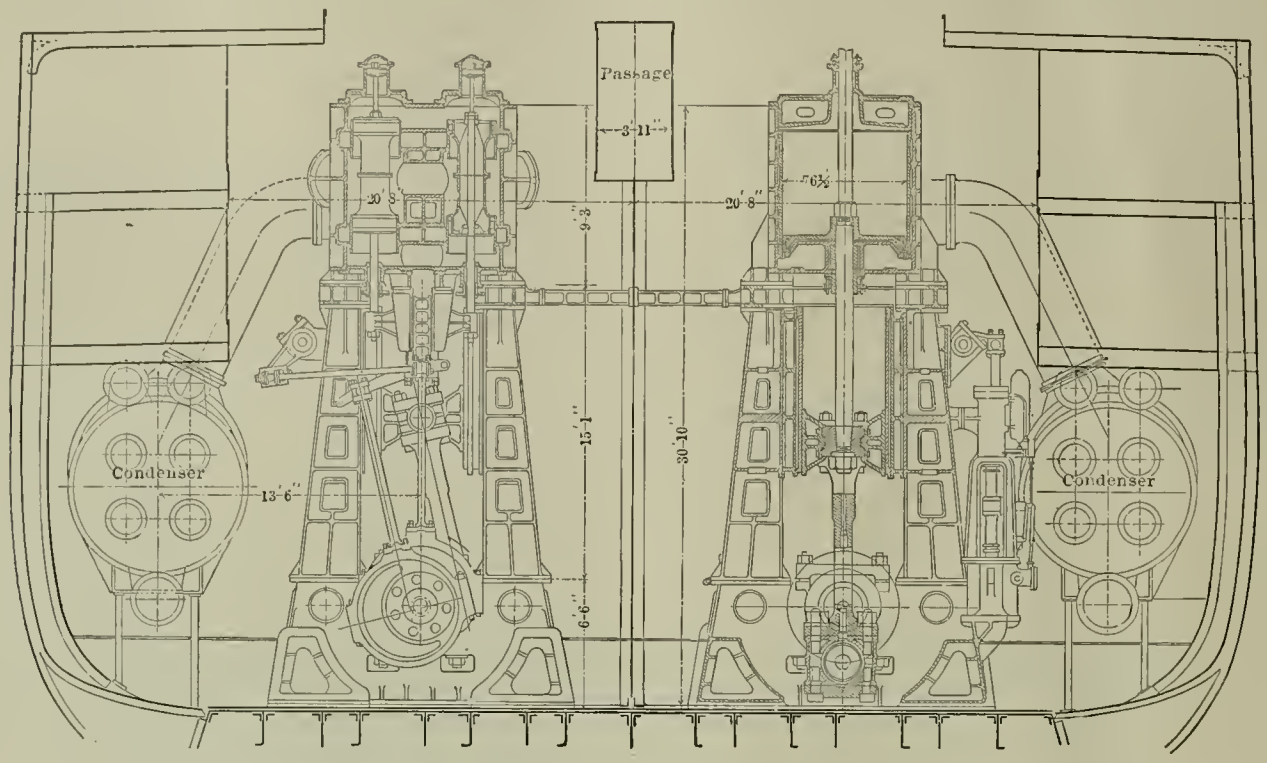
THE MAMMOTH ENGINES OF FRENCH LINER LA PROVENCE, AS ERECTED IN THE SHOP.

feet), and the heating surface 5,420 square meters (58,172 square feet). The ratio is 37 to 1. The total water volume is 600 cubic meters. The safety valves are set at 14 kilograms per square centimeter (198 pounds per square inch), which is only slightly above the pressure at which steam enters the high-pressure cylinders. For auxiliary machinery this pressure is somewhat reduced by special expansion valves, but in general the engines operate at boiler pressure.

partments containing a bundle of tubes traversed by the gases of combustion, which here give up a part of their heat. The air is, therefore, hot when it enters the furnaces, and combustion takes place under the best possible conditions. Thanks to this arrangement, the engines have been able to develop on trial more than 200 horsepower per square meter of grate (18.6 horsepower per square foot), with ample steam furnished by the boilers. In addition to the main boilers, there are on board two

boilers which are used only in harbor, when the larger units are extinguished for examination or any repairs which they may need.

heaters, in which it is heated by the exhaust steam from the auxiliary machinery. In addition to this, ventilators are interposed in the feed pipes of the pumps, operating by gravity.



TWO SECTIONS THROUGH ENGINE ROOMS, SHOWING GENERAL POSITION OF PROPELLING ENGINES.

The two main engines are identical in design, and are separated from each other by a water-tight bulkhead in the axial plane of the ship. They are of the four-cylinder triple expansion type, with the high-pressure cylinder forward and two low-pressure cylinders aft. The cylinder diameters are respectively 1.2, 1.94 and 2.242 meters (47¼, 76½ and 95¾ inches), with a common stroke of 1.7 meters (67 inches). The number of revolutions per minute is 90, corresponding with a piston speed of 4.54 meters per second (894 feet per minute). The valves of the high-pressure and intermediate-pressure cylinders are of the piston type, while those of the low-pressure cylinders are balanced slide valves. The surface condensers have each a cooling area of 1,652 square meters (17,750 square feet, or 1.184 square feet per horsepower). Before being again fed to the boilers, the water leaving these condensers passes through re-

The circulation of water in the condensers is made by means of centrifugal pumps operated by special motors. The air pumps and the feed pumps are independent, and of the Weir system. Each main engine is provided with two by-pass valves which permits sending the steam into the intermediate or low-pressure cylinder. They possess both a steam and a hydraulic reversing engine, the latter serving also as a check to prevent increase of speed of the shaft. The steam pipes are so disposed that in case of accident it would be possible to cut out the cylinder affected, and operate with the other three. The total length of the shafts is 66.7 meters (219 feet). They are all of nickel steel, hollow, tempered and annealed. The thrust shaft operates against a system of horseshoe collars, thirteen in number.

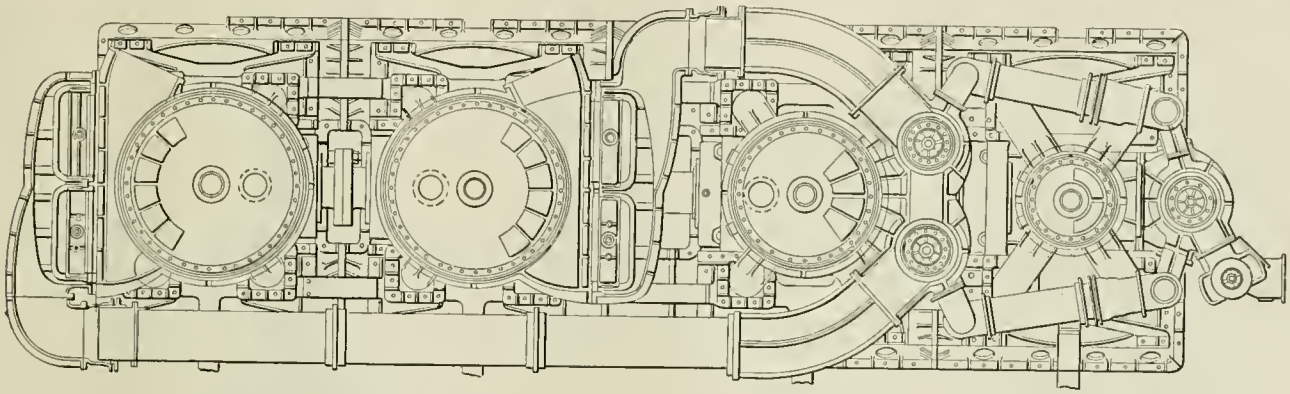
UPPER PLATFORM IN THE ENGINE ROOM.

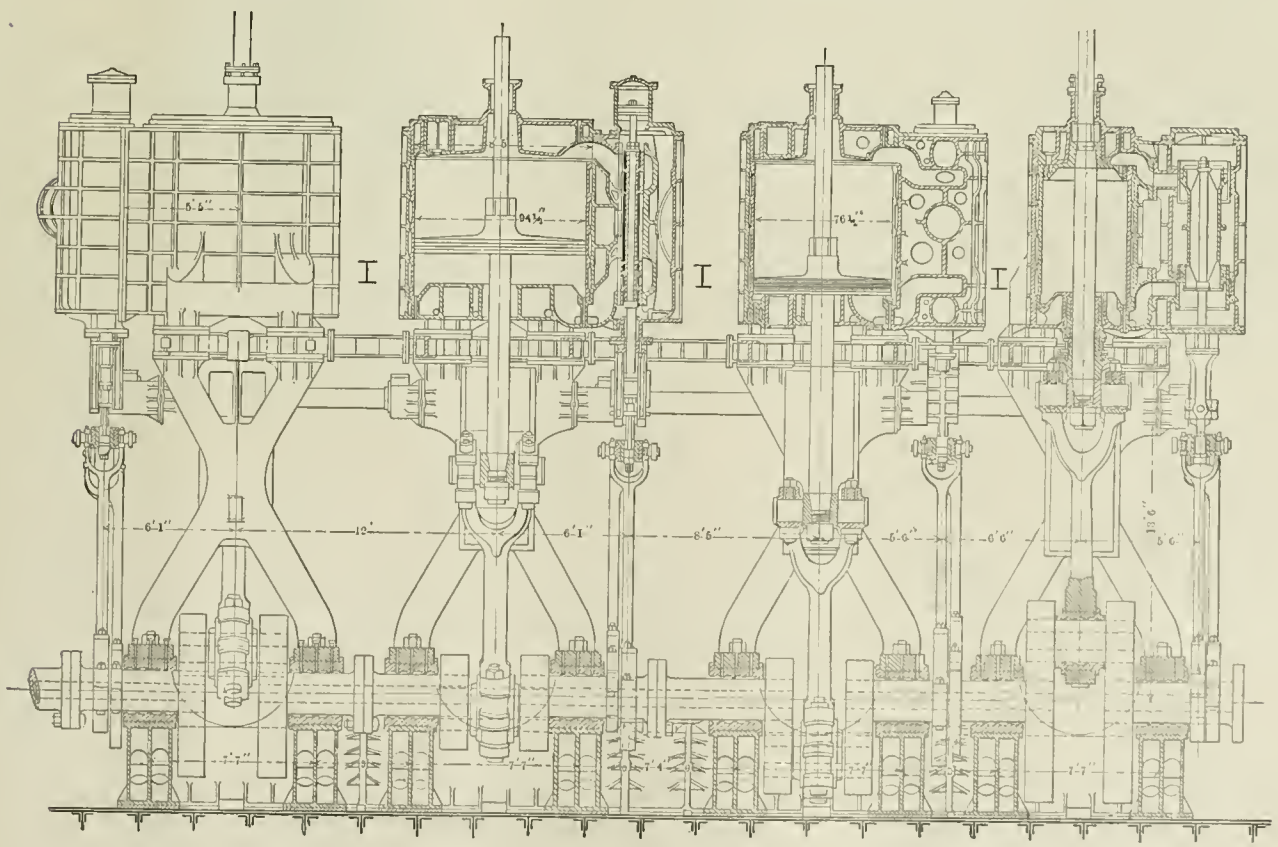
SHELTERED CAFE ON UPPER DECK.

The two screws have each four blades, the total diameter being

A CORNER OF THE WRITING AND MUSIC ROOM.

DRAWING ROOM FOR FIRST CABIN PASSENGERS.





LONGITUDINAL SECTION AND PLAN VIEW OF PORT ENGINE ON FRENCH LINE STEAMER LA PROVENCE.

6.5 meters (20 feet 4 inches). The entering pitch is 8.4 meters (27 feet 6 inches), and final pitch 9.2 (30 feet 2 inches), giving a mean pitch of about 8.8 meters (28 feet 10 inches), and a pitch ratio of 1.35. The blades are of manganese bronze, with a tensile strength of 50 kilograms per square millimeter (32 tons per square inch), and elongation of 20 percent.

All the pumps are independent and operated by separate motors. The bilge pumps, two in number, have a capacity of 200 cubic meters (205 tons) per hour, and may by means of the piping system serve all the compartments in the ship. The freeing of the different main compartments of the ship is assured by five steam pumps with a capacity of 400 tons per hour each, and by six ejectors. The fire apparatus connects with the pumps by means of water pipes continually under pressure and is completed by six portable extinguishers.

E.O.

COLD STORAGE ON BOARD SHIP.

PART III.

BY SYDNEY F. WALKER, M. I. E. E.

COOLING THE CHAMBER BY COOLING THE AIR.

This is the more frequent method adopted where fruit is carried, and it is the method that is coming more and more into vogue on shore, wherever it can be arranged. It enables the engineer to have a greater command over his work. But before describing the arrangements for this, another important matter, the ventilation of cold chambers, a matter leading directly to the process of cooling the air entering the chamber, should be considered. The proper ventilation of cold chambers is a very troublesome problem, and it is the troubles encountered in connection with this which, the writer believes, have led very largely to development in the direction of cooling the air itself.

In all cold chambers in which produce is stored a certain quantity of carbonic acid gas is formed, and other gases are also given off, which are more or less deleterious to the produce, and should therefore be kept at as low a percentage as possible. But the air which is laden with these gases can be got rid of only by allowing other air to enter and take its place, while the cleansing action that is advisable—the action of air in the process of ventilation is very similar to that of water in the ordinary processes of cleansing—demands that the fresh air shall be allowed to penetrate to every part of the chamber, and to reach every surface of the produce. But if outside air is admitted, it is usually at a higher temperature than that inside the chamber—there are exceptions which will be noted—and the incoming air brings heat with it. This may not be a serious matter, where it is known and provided for. Every time the door of the chamber is opened, to put in or take out produce, or for the entrance or exit of the attendant, the same thing happens, to an extent depending upon the construction of the doors and the care of the attendant.

In many cases no other provision is made for ventilation, but the best practice provides for its being carried out in a thoroughly scientific manner, and in such a manner as to assist the convection currents that are of so much use in distributing the cooling influence of the brine or expansion grid. Wherever the grid is placed, it will be understood, the air in its immediate neighborhood will feel the effect first, and this, becoming heavier as it cools, will tend to fall, allowing the lighter air to take its place. In some cases the convection currents so set up are hardly sufficient to distribute the cooling effect of the pipes to the produce efficiently, and this leads to a larger expenditure of coal and accessories. Where the grid is placed on the side of the chamber, for instance, the convection currents are sometimes very sluggish. The ventilation and the convection currents are assisted by fans, placed in any convenient position, driven by any convenient source of power, usually electric motors. The fans are arranged either to suck the air out of the chamber, an inlet being provided in another part, at a distance from the outlet, or to force the air into the chamber, an outlet being provided at the other end. The outlet should be a little above the floor line, in the great majority of cases, as the carbonic acid gas is heavier than air, while the inlet should be near the ceiling, at the opposite end. Fans should be arranged to assist the circulation of the air in the chamber, apart from the outside circulation.

The actual arrangement will vary with each case, and the engineer in charge will have to be guided by the condition of the cold rooms. In some cases the fan may be kept running continually to assist the convection currents within the chamber, there being no ingress of air to the chamber except at certain fixed times and for certain limited periods, and the entrance of the outside air being controlled by valves, opened from the outside. In a few cases it is possible to allow a small current of air to pass through the chamber all the time, remembering that it

BRUNSWICK ONE-TON COMPRESSOR.

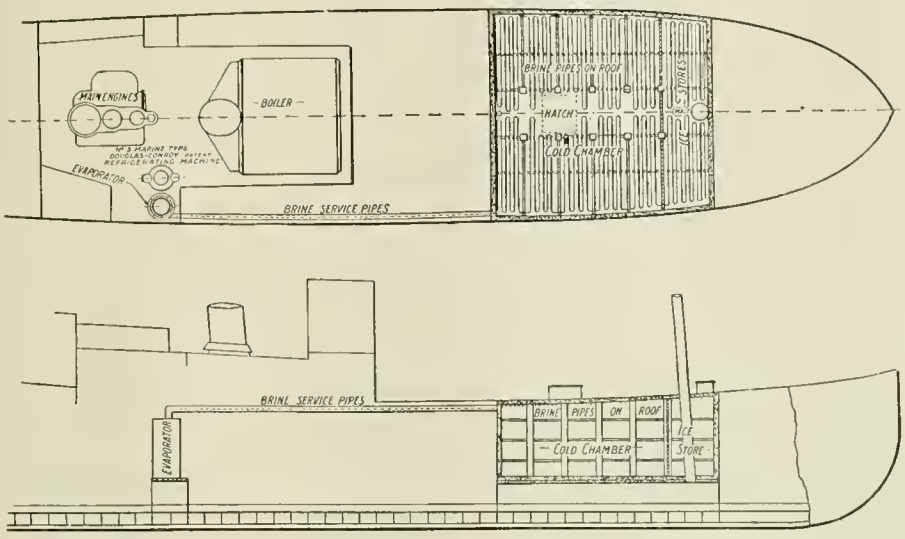
brings heat with it, and that the heat so brought must be abstracted, and further that it will be in proportion to the difference in temperature between the air from which the supply is taken and that of the chamber. The incoming air will bring moisture, which again must be abstracted, and this means the further abstraction of heat.

The quantity of heat brought in by the incoming air is found by multiplying the quantity of air passing in by the difference in temperature between it and the air of the chamber, and by the specific heat of air. We may take the specific heat of air as 0.2, it being neither at constant volume, nor at constant pressure. The weight of a cubic foot of dry air at 60 degrees is approximately 0.08 pound, so that there are 12.5 cubic feet of air in one pound, and one heat unit will, therefore, raise the temperature of 62.5 cubic feet of air one degree F. Conversely, air which is at a temperature of 60 degrees F., entering a cold chamber in which the temperature is say 10 degrees, will bring 50 heat units with every 62.5 cubic feet, or one heat unit with every 1.25 cubic feet, and with a chamber of 10,000 cubic feet capacity it would require the services of a machine capable of producing a ton of refrigeration in twenty-four hours, to deal with this in one hour, or a proportionately larger machine if it had to be dealt with in a shorter time; and this does not take any account of the moisture brought in. The question whether

this extra work shall be taken is one for consideration on the lines of the balance sheet. On one side should be put the deterioration of the produce, if any, that will take place if the store is not ventilated, and on the other the cost of the additional work involved in the removal of the additional heat.

Another important point must not be last sight of—the effect of the increased temperature upon the produce—but again this is a matter for careful regulation. The figures required are: how much air comes in, how much heat it brings with it, and how quickly the heat must be removed. This enables the work required to be calculated.

Evaporation is constantly going on at all temperatures, from the surface of any liquid exposed to the air, and from any objects, such as dress fabrics, wood, etc., in which liquids are held. So the air above and resting upon the surface of a liquid carries a certain quantity of vapor. This exerts a certain pressure upon the surface of the liquid, apart from that due to the weight of the air itself, while the vapor which is being given off from the surface of the liquid also exerts a certain pressure upon the vapor already in the atmosphere above. The pressure of the vapor coming away from the liquid depends upon the temperature of the liquid, while the pressure of the vapor in the air



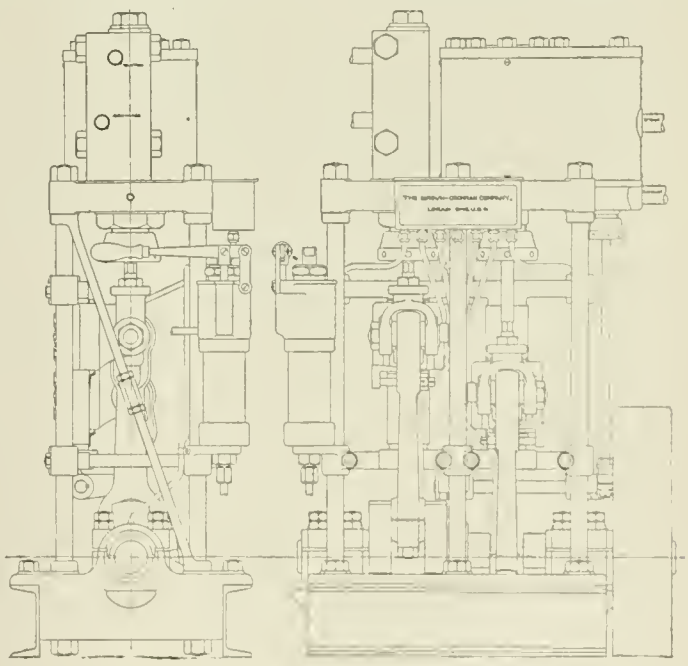
DOUGLAS MARINE INSTALLATION, SHOWING APPLICATION TO TRAWLER.

COOLING THE AIR ENTERING COLD CHAMBERS.

There are really two parts to the problem involved in cooling a chamber by cooling the air which enters it. There is the removal of the heat of the air itself, in order to reduce it to the temperature at which the air in the chamber is to be held; and there is the removal of the moisture held in suspension in the air. Both objects are accomplished at one operation, and both involve the abstraction of a certain number of heat units. Atmospheric air always holds moisture in suspension, the quantity held depending upon the temperature, and increasing very rapidly as the temperature increases. But the moisture in suspension is in the condition of vapor, and it can assume that condition only by absorbing a certain quantity of heat, from 900 to 1,000 units for every pound of water vaporized. The method of cooling wine by wrapping a wet towel around the bottle and putting it in the sun is well known; while the case of a man's wet clothes drying on his back and giving him a cold, will perhaps be more familiar. In both cases the heat necessary for evaporation is taken largely from the object upon which the damp fabrics are placed. In order, therefore, that the vapor held by the air shall be deposited, the latent heat of evaporation must be abstracted from it. The mere fact of cooling a certain quantity of air leads to the air's seeking to get rid of a portion of its moisture, and its deposition will lead to a rise of its temperature, owing to the delivery of heat by the vapor.

There is another factor in the problem of the deposit of the watery vapor from the air. The question arises, when will the vapor be deposited, and why? The capacity of air for absorbing the vapor of water varies, as shown in the accompanying curve. But the air is very rarely saturated with vapor, that is, it very rarely carries the full quantity of which it is capable, at any given temperature. In damp climates, in the winter months, it may carry as much as 85 or 90 percent of the quantity it would carry if saturated; while in dry climates, from 50 to 65 percent only will be carried.

above depends upon the temperature of the air, and the percentage of possible vapor carried. If the air and liquid are at the same temperature, and the air is saturated with vapor, no evaporation can take place, as the pressure of the vapor already in the



BROWN-COCHRAN CARBONIC ANHYDRIDE COMPRESSOR.

atmosphere, and of that issuing from the liquid, are equal. But where, as is nearly always the case, the air is not saturated, evaporation will go on until the pressures of the two vapors are equal. The converse of the above is also true. Where there is

a difference between the pressure of the vapor in the atmosphere and that of the vapor rising from some body with which it is in contact, in favor of the atmospheric vapor, the vapor will be deposited from the atmosphere, provided that it can deliver up its heat of vaporization to the surrounding objects.

Bearing in mind the fact that the capacity of air for carrying vapor rises rapidly with the temperature, it follows that any lowering of the temperature of the air immediately tends to increase the percentage of saturation, and to increase the vapor pressure, and its tendency to deposit. The vapor pressure is obtained by first finding the percentage of saturation of the air, by the wet and dry bulb thermometer; and then consulting a table that has been compiled from observation. From another table, also compiled from observation, the vapor pressure at saturation at different temperatures is obtained, the actual pressure of the vapor in the air, at the temperature to which it is reduced, being determined from these two tables, and the thermometer readings. The vapor pressure of the ice or snow on the brine or expansion grids used in cooling the air, as explained below, is also known, from its temperature—vapor is coming away from even ice and snow, if its vapor pressure exceeds that of the air in contact with it—and it will follow that when the vapor pressure of the air, at its reduced temperature, is greater than that of the vapor of the ice or snow, or the cooling brine, moisture will be deposited from the air upon the grid, or in the brine, the density of the brine solution being lowered in consequence.

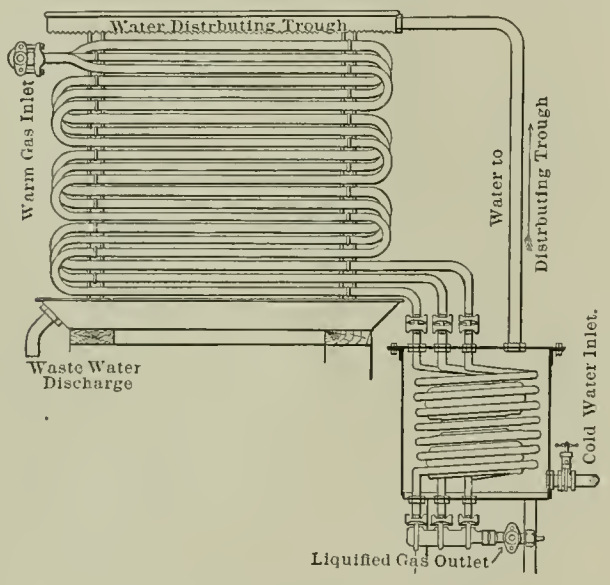


DIAGRAM OF WEST EVAPORATIVE CONDENSER.

The quantity of water per cubic foot of dry air, when the air is saturated, varies from 0.000079 pound at 0 degrees F., up to 0.0368 pound at 212 degrees F., and at ordinary barometric pressure. With air that is to be cooled from 70 to 15 degrees F., and deprived of its moisture, it is necessary to first abstract the heat carried by the air itself, and then to abstract that carried as latent heat by the vapor. The two operations go on together, but the calculation is made separately. Thus the air has to be cooled 55 degrees, so that each pound of air must be deprived of 11 units, and each cubic foot of 0.88 unit, or 880 units per 1,000 cubic feet. If we take the vapor saturation of the air as 72 percent, we find that the air will contain 0.0009 pound per cubic foot, or 0.9 pound per 1,000 cubic feet, and this will mean, approximately, that 900 heat units have to be abstracted, in order that the vapor may assume the liquid condition and be deposited. If it is formed into ice or snow, as usually happens, when the moisture is deposited on the grid, the latent heat of the liquid must also be abstracted, a further 128 units, or a total of 1,908 units per 1,000 cubic feet of the air to be cooled.

The above figures are given to enable marine engineers to see how the calculations are made, and how important is the question of the vapor in the air. The latter is changing from hour to hour, especially when a ship is changing her latitude somewhat rapidly, and therefore any calculations that are made should be on the basis of the worst conditions to be met. If the air is not properly dried, some vapor will pass into the cold chamber, and will there be deposited upon the cold surfaces of the produce. Hence sufficient refrigerating power should be provided to extract the largest quantity of moisture that will be encountered.

METHODS OF COOLING THE AIR.

There are three methods employed, though only two of them are applicable to the general run of ship work. The air may be caused to pass over the surface of brine that has been cooled to a low temperature; it may be caused to pass over the surface of a grid in which either brine or the refrigerant is circulating; or again, may be cooled by compression and expansion.

The first method is the most economical, and is largely employed in cold stores on shore. The usual arrangement includes cooling the brine in a tank through which the refrigerant is circulating. It is then carried to a point where it can conveniently be interposed in the path of the air. At this point a battery of galvanized corrugated iron plates is fixed, the plates being hung vertically. The brine is made to trickle down over the plates into a trough below, from which it is pumped back to the evaporating brine tank. The air, which has done its work in the cold store, or which is brought fresh from the outer atmosphere, is forced between the plates of the battery by a fan. In passing between them it is cooled, and its moisture and other substances that are not wanted are deposited in the brine, the air then passing on to the cold chambers. With this arrangement, the brine is diluted by the water taken from the air, and has to be subjected after a time to a process of partial evaporation; it is boiled in a pan having a steam jacket until its density is restored to the proper figure.

In the next plan a grid of pipes, somewhat similar to those that have been described for cooling the cold chambers themselves, is placed in any convenient position where the air can be forced through it on its way to the chamber. The air with ship work is taken usually from the atmosphere, in the first instance, by means of a shaft leading from the fan chamber to a sufficient height above the upper deck to insure its being free from stokehold odors, grease, etc. In many cases, however, the same air is used over and over again, being passed around through the fan and over the grid, after it has passed out of the chamber.

The fan chamber leads directly to the cooling grid, and is also connected to the exit ducts of the cold chamber, the engineer being able to arrange the air as he finds best, being guided in that by the condition of the produce. He also has it in his power to work directly from the atmosphere, without cooling the air at all, where the conditions warrant his doing so, the air being simply taken in from the atmosphere and expelled to the atmosphere again. The cooling grid is made in sections, each section being connected to a header, where valves are arranged, so that any section can be put into service or cut out at will, and the refrigerant, or the brine, circulates through the grid according to the requirements of the chamber. In hot climates the engineer may have perhaps all the sections in service, while as the ship passes into colder latitudes he will take off one section after another, and possibly in cold weather depend entirely upon the atmosphere for parts of the day.

As mentioned above, the moisture present in the atmosphere has a very important bearing upon the question, whether the air shall be used over and over again, or whether fresh air shall be admitted. When it is used in a closed circuit the quantity of moisture present and the temperature of the air coming from the chamber are known, and therefore the quantity of cooling the latter requires; but when fresh air is admitted from the outside, the engineer does not know, without testing, what its hygroscopic condition is, and how much cold will be required.

Hence it is simpler to use the same air continuously. The moisture that is present in the air condenses on the outside of the pipes of the grid, and is then frozen, the frozen skin acting very much as the trickling brine does with the battery of plates. When the machine is stopped, the mass of ice and snow melts and is collected in a trough provided for it under the grid, and disposed of in the usual way.

COOLING THE AIR BY COMPRESSION AND EXPANSION.

This method was employed a good deal in the early days of cold storage, especially for ship work, and it has a great deal to recommend it, even now, for small work, such as the cold store for ship's provisions in a small ship. For large work it is not so economical, and the quantity of air required is so much larger, as is also the apparatus to deal with it, that it has gradually fallen into disuse, except for special cases. On the compressed air system, air is taken from the atmosphere in the first instance, drawn into a cylinder which performs the office of pump and compressor, and is there compressed by the action of a piston. In the act of compression heat is generated in the air. Now, it would be fatal to the utility of the air as a cooling agent if any moisture were present. Hence, after passing through the compressor, the hot air is passed through a cooling and drying apparatus, where the heat which has been generated by compression is taken out, and any moisture it carried is deposited.

There are several forms of cooling apparatus for air, the principle being the same as already described for cooling the air going into the cold chamber, but there is no brine grid available. One plan is to pass the air through a cylinder containing a number of small glass balls, like marbles, over which a thin stream of water trickles. The air enters the cylinder at the bottom, and the water trickles down from the top. The air is gradually cooled as it passes upwards, and as it cools deposits the moisture it carries, so that it issues at the top of the cylinder partially cooled, and fairly dry. The principal cooling is performed in the next operation, in a second cylinder, whose piston rod is connected through its own crank to the same crank shaft as that of the compressor piston. This is called the expansion cylinder, and performs the same office as the expansion coils where a refrigerant is employed. The air which has been cooled and dried is allowed to pass into the expansion cylinder behind the piston, which it works, expanding in the process. The cranks of the two pistons are set at right angles to each other, so that the work which the expanding air performs on the expansion piston assists the compressor piston. In expanding, the air is cooled, and as air or any other gas can expand only if it has the space, and can obtain the necessary quantity of heat to enable it to do so, it abstracts heat from surrounding bodies and becomes itself lowered in temperature. The compression stroke of the compressor coincides with the expansion stroke of the expansion cylinder, and at the suction stroke of the compressor, the piston of the expansion cylinder forces the cooled air out to the cold chamber, or wherever it is to go.

The cooled air is employed only to dilute the air of the cold chamber, so that the temperature of the latter is carried at whatever figure may be desired. The calculation for the quantity of air to be cooled, and the temperature at which it shall be forced into the cold chamber, is simple. Each cubic foot of the cold air will absorb a certain number of heat units while its temperature is being raised to that of the air in the cold chamber, the temperature of the latter being lowered in the process; but it must be remembered that as the entering air rises in temperature, it also increases in volume, and the cooling effect of a cubic foot of air, at each succeeding temperature, becomes less and less.

In practice the average is taken, through the range of temperature. The air after expansion may be at as low a temperature as —85 degrees F. Some makers of compressed air refrigerating apparatus claim to reduce it to —100 degrees F. Taking it at —85 degrees F., and taking the mean between this and the temperature at which the cold chamber is to be held, say 15 degrees F., or a difference of 50 degrees, every 100 cubic feet will absorb 80 heat units.

(*To be continued.*)

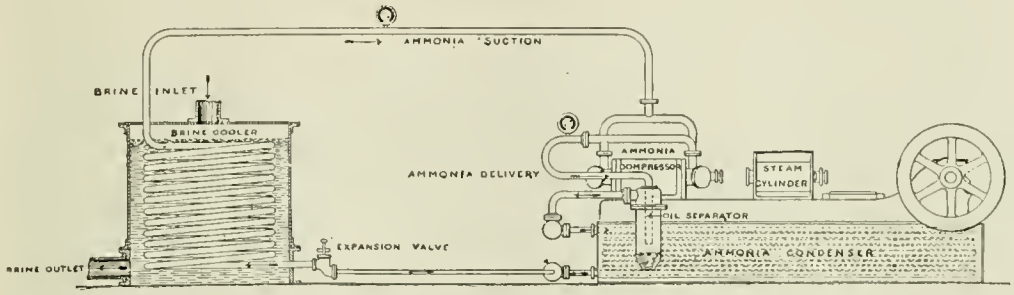


DIAGRAM OF HASLAM AMMONIA OUTFIT, SHOWING THE SEVERAL PARTS OF THE APPARATUS.

Progress of Naval Vessels.

The Bureau of Construction and Repair, Navy Department, reports under date of July 11, 1906, the following percentage of completion of vessels building for the United States Navy:

			June 1	July 1
BATTLESHIPS.				
Nebraska	19 knots.	Moran Brothers Co.	94.	95.16
Georgia	19 "	Bath Iron Works	96.7	97.47
Connecticut	18 "	Navy Yard, New York, N. Y.	97.41	97.41
Vermont	18 "	Fore River Shipbuilding Co.	85.	88.5
Kansas	18 "	New York Shipbuilding Co.	82.2	85.2
Minnesota	18 "	Newport News Co.	89.76	91.44
Mississippi	17 "	Wm. Cramp & Sons	57.67	59.85
Idaho	17 "	Wm. Cramp & Sons	55.73	58.07
New Hampshire	18 "	New York Shipbuilding Co.	45.7	48.
ARMORED CRUISERS.				
California	22 knots.	Union Iron Works	93.3	94.
South Dakota	22 "	Union Iron Works	91.1	91.8
Tennessee	22 "	Wm. Cramp & Sons	98.97	99.75
Washington	22 "	New York Shipbuilding Co.	98.2	99.
North Carolina	22 "	Newport News Co.	46.35	50.5
Montana	22 "	Newport News Co.	41.32	44.72
SEMI-ARMORED CRUISERS.				
St. Louis	22 knots.	Neafie & Levy Co.	96.78	98.77
Milwaukee	22 "	Union Iron Works	95.2	96.1
SCOUT CRUISERS.				
Chester	24 knots.	Bath Iron Works	32.34	36.88
Birmingham	24 "	Fore River Shipbuilding Co.	34.7	38.4
Salem	24 "	Fore River Shipbuilding Co.	35.7	39.3
SUBMARINE TORPEDO BOATS.				
Submarine No. 9	.....	Fore River Shipbuilding Co.	72.5	75.9
" " 10	.....	Fore River Shipbuilding Co.	57.6	62.
" " 11	.....	Fore River Shipbuilding Co.	64.1	72.3
" " 12	.....	Fore River Shipbuilding Co.	56.9	59.

Personal.

James Nelson Alexander has been transferred from the office of the Inspector of Machinery of the United States navy at the Neafie & Levy Shipbuilding Company, to the same office at the shops of the New York Shipbuilding Company, Camden, N. J.

SAN FRANCISCO HARBOR.*

BY CHARLES GRLEN.

A thousand causes have tended to center population around San Francisco Bay, producing the phenomenal growth of San Francisco, the business center of the Pacific coast region. This is not because of any temporary advantage, but in consequence of its inherent advantage of location. Nature never designed a more beautiful environment. Located on a commodious bay forming one of the finest landlocked harbors in the world, with a depth of from fifty to three hundred feet, and rivaling Naples in picturesque scenery, San Francisco undoubtedly, by natural advantage and impetus, will continue to retain its preeminence on the coast.

This can be especially said of Oakland, Berkeley, Alameda and Sausalito, and the surrounding territory, where thousands of commuters ferry to and from San Francisco daily. Judging from the growth of these towns in the past few years, it appears probable that there will soon be a continuous city over twelve miles long, and extending back to the foot hills.

The distance between the water fronts of San Francisco and Oakland is about six miles, but the ferryage has been reduced to four miles by building long moles and wharves out into the bay. The time occupied in crossing is about seventeen minutes. The tourist, on arriving at Oakland, the terminus of the Southern Pacific Company, is given an excellent view of San Francisco and its harbor, while crossing on the largest ferryboats in the world. These boats, the *Oakland*, *Berkeley* and *Newark*, were

GENERAL VIEW OF THE UNION IRON WORKS, FROM THE BAY.

MONITOR WYOMING ENTERING HYDRAULIC DOCK.

especially designed by the Southern Pacific Company for this route, and have a seating capacity of 2,000 people each. The *Oakland* and *Newark* are of the side wheel type, driven by powerful beam engines, while the *Berkeley* is of the double screw type, with one screw on each end, working on a continuous shaft, and the motive power consisting of an inverted triple expansion engine. Both types of boats burn oil for fuel, this being almost universally used on the boats in the harbor.

The boats pass close to Goat Island, which reaches up some four hundred feet above the water, and on which is located the naval training school. From this point the city makes an impressive appearance, especially at night, when ablaze with lines

ONE OF THE LARGEST PASSENGER FERRYBOATS AFLOAT.

of lights climbing the hills. The harbor is also in full view, with vessels from all parts of the world. Nearly every type of steam craft is represented, among others being stern wheels of the Mississippi river type, lumber schooners, army transports, whalers, and full rigged ships.

The use of the steam schooner is confined exclusively to the coast of California, usually on short runs of two hundred to three hundred miles. These schooners are fitted with both sail

One chief advantage is the cheap and rapid transportation facilities, relieving the congestion of the centers of population and carrying the people off into the rural districts across the bay; thus giving to the workingmen an encouragement to work in such a city, and to live where one or more acres of ground can afford the family all the pleasures and healthfulness of country life, with the economies which result from the high cultivation of small pieces of land for household use.

*Written before April 18, 1906.

and steam as motive power, a typical length being 150 feet, beam 34 feet, and depth 17 feet. Many are fitted with triple expansion engines and water-tube boilers. The stern wheelers are used principally for duty on the shallow rivers, many of the largest ones plying between San Francisco, Sacramento and Stockton.

UNITED STATES BATTLESHIP OHIO ALONGSIDE WHARF AT UNION IRON WORKS.

In 1902 the Pacific Mail Steamship Company brought out two of the largest vessels ever built in the United States, the *Korea* and *Siberia*, of 11,276 tons. The *Mongolia* and *Manchuria*, which arrived two years later, have a gross tonnage of 13,639. Each of the latter is 615 feet 8 inches long, 65 feet beam, 51 feet 3 inches deep, and has a load draft of 33 feet 6 inches. There are four masts, five complete decks, ten watertight bulkheads, and bunkers capable of carrying 2,800 tons of coal. They are driven by bronze twin screws 18 feet 6 inches in diameter, operated by engines of the four-cylinder triple expansion type, developing 10,000 indicated horsepower.

THE OHIO IN THE BIG DRY DOCK AT HUNTER'S POINT.

PACIFIC MAIL STEAMSHIP MONGOLIA, 13,639 TONS, IN DRY DOCK AT HUNTER'S POINT.

The Occidental and Oriental Steamship Company operates a fine line of steamers, three of which are almost as large as the *Korea* and *Siberia*. The passenger accommodations and appointments on all these vessels are very beautiful, and the color schemes of woodwork, painting and draperies most pleasing, every detail being carefully studied and carried out.

OUTWARD BOUND.

The increasing commerce across the Pacific required these mammoth vessels, nearly all goods made in this country having found a market across the water. Under the guidance of far-sighted men, exports alone to the Orient have grown over 50 percent within a few years. As an immediate evidence of the practical results of this development, outgoing freight upon all lines of steamers shows a steadily growing volume and variety of commodities.

That the shipbuilding industry has been a prime factor in the building of San Francisco can be appreciated by considering the

UNITED STATES SUBMARINE BOAT IN THE BAY.

fact that the Union Iron Works, during the past seventeen years, has secured contracts for building twenty government vessels of every variety, of a total cost of over $28,000,000, and giving employment to an average of 3,500 men. These works, which are located within twenty minutes ride of the center of the city, are equipped with five building slips, and all the modern tools and appliances for building and repairing all types of vessels. The equipment includes a hydraulic dry dock capable of lifting a five-thousand-ton vessel, and sheer legs of 150 tons capacity. This plant has the reputation of turning out some of the finest work

of its kind in this country, manufacturing every detail involved in the construction of ships, including windlasses, steering engines and complete generating sets.

At present the United States cruisers *California*, *South Dakota* and *Milwaukee* are nearing completion; and the hulls being erected for the new 500-foot American Hawaiian Steamship Company's vessels. Besides the construction of vessels, this company makes a specialty of mining machinery, having equipped the largest mines on the coast.

VIEW OF PROTECTIVE DECK OF CRUISER MILWAUKEE, BUILT BY THE UNION IRON WORKS.

STEAMER COLUMBIA TIPPED OVER IN DRY DOCK.

Among the other shipyards are the plants of the Risdon Iron Works and the Fulton Iron Works, which also enjoy the reputation of building first class vessels for local trade. Along the harbor will also be seen many dry docks of the floating type. These docks are almost constantly in use, and a thriving business is done in this line. The largest docks are located at Hunter's Point, having lengths of 700 and 450 feet, respectively, and capable of docking the largest vessels. With these and many other industries, the docks of the different steamship and railroad lines, and the handsome ferry building with its seven slips, San Francisco harbor presents a scene of activity that well justifies the Golden Gate's being termed the front door to the Orient.

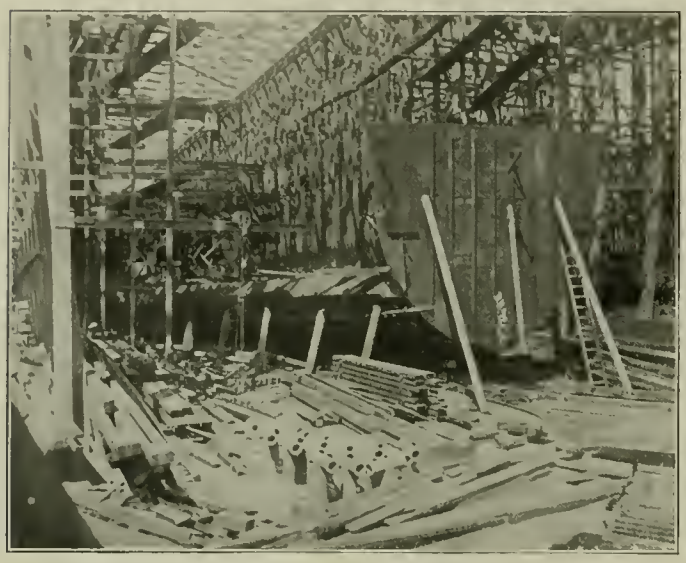
The above article was written before the terrible disaster which overwhelmed the city of San Francisco in April. As a general proposition, while a great deal of wharf property was seriously damaged by the earthquake, the damage to shipping was slight. In the yard of the Union Iron Works, two large steamers were under construction for the American-Hawaiian Steamship Company, and a third had been started. The two which were well under way were pitched forward and dropped from the keel blocks, being somewhat warped, but not seriously damaged. One of our photographs shows the condition of one

FERRYBOAT FRAMING THROWN ON BEAM ENDS.

of these steamers a few days after the earthquake, and gives little indication of trouble.

In dry dock in the same yard was the steamship *Columbia*, of the Oregon Navigation Company, the necessity for some slight repairs having accounted for her position. The shock damaged the bottom of the dock, and threw the *Columbia* over against the side walls, tilting her to an angle of about 45 degrees. In the meanwhile water rushed into the dock and quickly filled the ship. So far as a hasty survey indicated, the ship received no serious damage.

The *Columbia* is an iron steamer measuring 310 feet by 38 feet 4 inches by 22 feet 2 inches, and has gross and net tonnages of



THE AMERICAN-HAWAIIAN LINE STEAMER.

2,722 and 1,746 respectively. She was built in 1880 by Roach & Son, of Chester, Pa., and is fitted with a compound engine of 2,100 indicated horsepower. The cylinders measure 37 and 82 inches in diameter by 42 inches stroke. Steam is supplied by four cylindrical return tubular boilers with a diameter of 12 feet and a length of 11 feet 1 inch. The working pressure is 130 pounds per square inch, and the boilers are fitted for the use of liquid fuel.

The steamship *City of Puebla*, of the Pacific Coast Steamship Company, which was lying alongside the wharves waiting for repairs, was seriously damaged by being struck with a pair of steel shear legs, which toppled over on her from the pier. These crushed part of the upper works of the ship, and punched a hole in her port side at the water line. The injury has been repaired.

The *City of Puebla* is an iron steamer, built in 1881 by William Cramp & Sons, of Philadelphia, and measures 319 feet by 38 feet 6 inches by 26 feet 3 inches. Her gross and net tonnages are respectively 2,624 and 1,713. She is propelled by a compound engine with cylinders 43 and 86 inches in diameter and 60 inches stroke. Steam is supplied by four cylindrical return tubular boilers, 14 feet 10 inches in diameter and 13 feet 4 inches long, operating at a pressure of 115 pounds.

The Bureau of Navigation of the Department of Commerce and Labor reports the construction during July of 113 vessels amounting to 31,026 gross tons. This includes ten vessels propelled by steam and aggregating 29,662 tons, of which 4, amounting to 25,681 tons, were built on the Great Lakes. These four are all of upwards of 4,800 tons. The remaining 109 vessels have an aggregate of 5,345 tons, or an average of 49 tons each.

PNEUMATIC TOOLS AS APPLIED TO SHIP CONSTRUCTION AND THEIR ADVANTAGES TO SHIPBUILDERS AND ENGINEERS.*

BY CHARLES SCHOFIELD.

About three years ago the shipyard managers of the United States decided to ascertain whether pneumatic tools as applied to ship construction were a financial success or not, and what actual advantages accrued from their use. They appointed a committee, instructing them to make the necessary inquiries from the various shipbuilders of America, and report the result of their labors at the next meeting. The paper presented caused more discussion and diversity of opinion than any other topic during the whole session. The reports of the various shipbuilders as returned disclosed a most satisfactory state of affairs, and proved beyond a doubt that pneumatic tools as applied to ship construction were a known quantity and beyond the experimental stage. The information thus obtained was not only interesting but instructive to the members generally.

I will endeavor in my paper to explain the methods adopted in the American shipyards as to the application of pneumatic tools in ship construction, also the cost of same, and make a comparison with the British piece-work hand rates.

PNEUMATIC CHIPPING HAMMER.

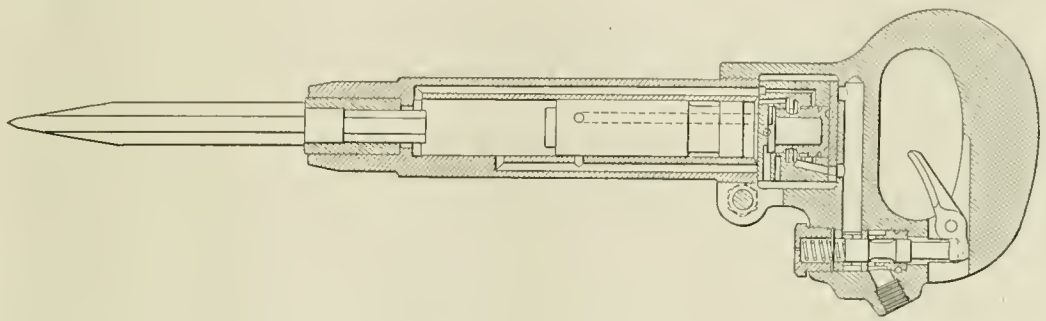
The first portable pneumatic tools introduced to shipbuilders were chipping hammers, Fig. 1. A pneumatic chipping hammer consists of a working cylinder, having attached to it a grasping handle, and inclosing a reciprocating piston and a valve box containing a reciprocating valve. In the lower part of the handle the air-inlet passage is situated, and is controlled by a piston throttle valve arranged therein, adapted to be operated by a pivoted finger lever. The air, after passing the valve, enters the transverse passage, which communicates with an annular groove situated immediately adjacent to the valve box. This groove serves to distribute the air to the various inlet ports and passages in the valve box. The valve box itself is in the form of a hollow cylindrical block bored out to two different diameters to receive the valve corresponding in shape. The valve box is provided with the necessary ports and passages to admit live air to and exhaust from the opposite ends of the cylinder, and for controlling the valve itself in coöperation with the piston. The valve contains no ports or passages, but has two grooves, one cut in the portion of small diameter, and one in that of large diameter. It will be seen that the valve, being made of two diameters, has two pressure surfaces or areas, against the smaller of which air constantly acts to press the valve in one direction; and against the larger area, air under pressure is intermittently admitted through the ports and passages in the valve box and cylinder, those in the cylinder being so controlled by the piston as to move the valve in the opposite direction against the constant live-air pressure on the smaller area. The piston is a solid cylindrical bolt having a groove in its periphery near one end for the purpose of placing in communication with each other the live-air passage, shown in dotted lines leading from the source of supply to the piston chamber, and another passage leading from the piston chamber to the larger area of the valve. The outer end of the cylinder is partly closed by means of an internal ring and the working tool's socket. When the working tool is inserted into the tool socket the closure of the end of the cylinder is thereby completed.

In the illustration the valve is in such position that the air is in contact directly with the piston so as to force it forward at high speed until it hits the tool end. When the portion of reduced diameter of the piston comes opposite to the end of the live-air passage, and puts this into communication with the passage leading back to the large area of the valve, the position of the valve is immediately reversed, whereby the live air passes round the groove in the portion of the valve of large diameter into the passage on the opposite side at the front of the piston,

*Read before the North East Coast Institution of Shipbuilders and Engineers, November 24, 1905.

forcing the same in a backward direction. The piston on its return stroke cuts off the supply of air from the larger area of the valve, and the latter returns to its initial position, admitting air behind the piston for the next stroke.

It was with fear and trembling that we, the shipyard managers, attended the several demonstrations prepared for our edification by the various pneumatic tool companies, as, of course, we were expected to try the tools; and sometimes we thought the piston was taking air at the wrong end on account of the excessive vibration, but this was eventually minimized by the makers adding a little more weight to the hammers. After we had got accustomed to handling the tools and had overcome, to some extent, our prejudice, it became evident to us that the pneumatic chipping hammer had some merit; inasmuch as it could do work in close quarters much better and in less than half the time the same work could be done by hand.



SECTION OF PNEUMATIC CHIPPING TOOL.

It was, however, months before we could get the men using pneumatic tools to admit that there was sufficient benefit derived from their use to warrant a reduction from the hand piece-work rate, and it was only by playing our cards diplomatically that we got our first reduction of 40 percent on all chipping and cutting, because, at this time, the men experienced great difficulty in chipping a plate edge to a bevel, or when dressing a shell butt, on account of the hammers having round bushings to take the shank of the chisel, whereby the man operating the tool had to twist the chisel as best he could without any assistance from the hammer. But all the up-to-date hammers of to-day have hexagon bushings, and the chisels have hexagon shanks to suit, so that the operator can twist the chisel to any desired angle by twisting the hammer, while a calking iron with a round shank can be used in the same hammer without the bushing being changed. The current piece-work rate for pneumatic chipping, solid cutting and calking in the United States is about 50 percent less than the piece-work hand rates of Great Britain; that is, taking the day-work rates of both countries as a basis. Another feature of the pneumatic calking hammer is that it calks the toe of the gunwale, waterway, tank margin and bulkhead bounding bars without their having been either planed or chipped. This allows the builder to order the said angles the same size as he would if they were not to be calked.

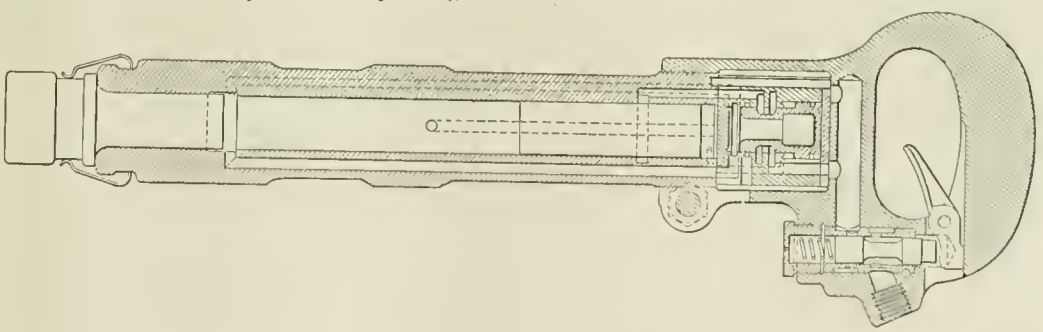
Pneumatic hammers are used extensively by engineers for dressing propeller blades, the palms of struts for vessels with twin screws, bed plates, cutting key ways, cleaning castings, etc., in fact, there is very little hand chipping done in the fitting shops of the American engine builders.

PNEUMATIC DRILLS.

When pneumatic drills were first introduced to shipbuilders they had to compete with electric drills of all sizes and weights; and during a four weeks' test at the works of William Cramp & Sons, of Philadelphia, the pneumatic drills proved their superiority. At the time of the test we were building three cruisers and two battleships, which had protective decks made up of two plates, each 1½ inches thick, connected by 1¼-inch rivets. It was on these plates we made the test, the average for the twenty-four days being as follows:

	Holes drilled.	
	Pneumatic.	Electric.
Air pressure on 12 days, being 90 pounds	248	100
" 9 " 84 "	232	100
" 3 " 76 "	208	100

The result was that we dispensed with twenty-six electric drills, and took 60 percent off the piece-work rate of drilling on this class of work; we also made a reduction of 60 percent on the price of holes drilled in the deck plating for deck planking, and took 50 percent off all other drilling on the ship, except odd work.



SECTION OF PNEUMATIC HAMMER.

Pneumatic drills are now used for every conceivable purpose by American shipbuilders, among others, cutting out side-light holes, ventilator and coal port-holes in the deck, boring stern-post gudgeons, wood backing for armor-plate bolts, tube cutting, tube expanding, tapping for stay bolts, screwing in stay bolts, and by using a speed reducing gear attached to the drill it is possible to tap up to 4 inches diameter, and to operate this combined machine only one man and a boy are required. In fact, the pneumatic drill is an indispensable factor in connection with speedy and economical ship construction in its various branches.

PNEUMATIC RIVETING.

Probably the hardest manual labor in all the various operations in building a ship is that of riveting. Combined with this is a certain amount of technical skill acquired only by an apprenticeship at the trade. A first-class riveter on inside work cannot properly drive shell rivets and *vice versa*, while the boiler riveter,

however good he may be at his own work, is of little use on any part of the ship's hull. In addition to this, the rapidly increasing size of ships, with the corresponding necessity for heavier plating, doublings, etc., requires the use of larger and longer rivets, which cannot properly fill the hole when driven by hand, however skilful or willing the men may be. For all these reasons combined, in the yard of the Cramp Company, of which I was the shipyard manager, some seven years ago a determined effort was begun and an extended series of experiments entered upon to develop pneumatic machinery capable of being operated by unskilled labor, by which all the rivets in the ship could be driven. This effort has been entirely successful, not only at Cramp's, but at all the leading shipyards in the States.

I recently sent to the four leading shipbuilders in America a letter asking them to cable me the approximate percentage of the entire number of rivets in the shell of a ship which they were now driving with pneumatic tools.

I received the following cablegrams in reply:

"Eighty-five to ninety."—James Wallace, Managing Director for the American Shipbuilding Company.

"Thirty shell, eighty hull."—Orcutt, President of the Newport News Shipbuilding Company.

"One hundred."—Wilson, General Manager, Marine Department, The Maryland Steel Company, Sparrow's Point.

"Ninety-nine."—Cramp's.

The last cablegram was confirmed by letter.

We had in use, at that time, a stationary riveter of the ordinary type, driving rivets in such portions of the ship as could be assembled and handled as a whole, namely, frames, water-tight doors, etc., such as are usual in ordinary merchant vessels. A very short experience with compression riveters showed that their great weight—reaching over 2,500 pounds for a six-foot gap—interfered too much with facility of handling to make them either useful or economical.

We then turned our attention to the pneumatic hammer, which delivers an almost continuous series of blows against the end of the chisel, calking tool, or rivet die. The hammer is light, powerful, short enough to go in between frame spacings, and small enough in diameter to get at rivets in corner angles. For rivets up to ¾ inch diameter it can be held in the hand, but for rivets of a larger diameter the hammer should be held in a device suitable to the location of the work on the vessel, for instance, shell device and deck device. It is, however, almost impossible to hold on to the rivet by hand unless a spring dolly bar is used instead of the heavy holding-on hammer used in hand riveting, the heavy holding-on hammer being fairly jarred off the head of the rivet by the rapidity of the blows from the pneumatic hammer, giving the holder-on no opportunity to bring his tool back into position between blows as in hand riveting.

PORTABLE PNEUMATIC YOKE RIVETER COMPLETE.

In connection with the above-mentioned pneumatic hammer there is used a simple pneumatic holder-on, consisting only of a cylinder carrying a piston, behind which air is admitted, the rod extending through the front head and being cupped out to go over the head of the rivet.

Combining these two machines with a yoke, the hammer being mounted on one arm and the holder-on on the other, makes a self-contained machine in which the yoke can be made very light, as it has to resist only the pressure of the air against the end of the holder-on cylinder, and the reaction of the hammer blows. Various sizes of these yoke riveters are used for riveting the center keelsons, longitudinals, side keelsons, etc. They are also extensively used for riveting certain parts of turrets, gun-carriages, etc., where first-class riveting is absolutely necessary.

For driving rivets in frames and brackets, intercostals and beam knees, etc., we use a jam riveter and pneumatic-holder-on.

The above descriptions will, I trust, make sufficiently plain the methods for driving all rivets that can be reached on both sides by a yoke or jam riveter. There remain three classes of rivets in a ship, as follows: (1) Those through decks and tank tops, mostly countersunk, and all driven downward from above; (2) bulkhead rivets, nearly all with full heads; (3) those in the outside of the vessel and all countersunk. These three classes must be reached by riveters on one side and holders-on on the other, without any connection whatever between them. The first class are most easily driven, and for them the hammer is attached to a universal swivel head, mounted on a pipe or T-bar. The operator raises the hammer to bring the flat die on to the rivet, and the pipe or T-bar being secured at the center, holds the hammer in position while the rivet is being driven. A second man with a pneumatic chipping hammer cuts off the surplus metal, and the riveting hammer being brought back on the rivet, a few seconds complete the operation. In this case the pneumatic holder-on is operated from below by a third man, being braced against the bottom of the ship or the next deck below.

For the second class, the hammer is simply held in the hands of the operator, said hammer having about a 4½-inch piston stroke, and as the die is cupped out to form the snap point, there is no tendency to slip off the point. The holding-on is done by a spring dolly bar, which I will explain later.

We now come to the third class, or shell rivets, which, in many respects, are the most important rivets in the ship, requiring the most careful workmanship and the best finish. Therefore it is a serious mistake for shipbuilders to attempt to drive shell rivets by pneumatic power until they have established pneumatic riveting on all inside work, because the men operating the tools should be accustomed to handling the hammers before being put on this important part of the work. It is evident at the start that the varying thicknesses of plates, frame flanges and liners, and especially the depths of countersink, render it impracticable to so gauge the length of rivet used that there will always be just enough metal to properly fill the countersink and finish the point, and that, therefore, as in hand riveting, a longer rivet must be used. After the point is beaten down and the surplus metal crowded off to one side, this surplus must be chipped off, and the point be finished up, rounded slightly, and any seams between the rivet and the plate driven together and closed. To do this a certain amount of freedom of motion must be allowed in the hammer, so that its axis may be inclined at a slight angle in any direction with the axis of the rivet itself.

This result is attained by mounting a pneumatic hammer in a device having a universal movement attached to the end of a T-bar, instead of its being immovably fastened to it. For bottom riveting there is a flat bar adapted so as to be mounted on the shell of a ship in any desired position. This flat bar carries an adjustable support, connected, by means of a swivel joint, with a holder in which is mounted an adjustable frame bar, pivotally supporting at one end a pneumatic hammer, and at the other an adjustable distance piece.

At one setting a space of 14 feet to 16 feet square can be reached with the above device, and when it is necessary to move the device to another position the change can be effected in about ten minutes. A spring dolly bar is used for holding-on, thus dispensing with the costly method of a wood backing, necessary when a pneumatic holder-on was used, as was the case a few years ago, and an ordinary pneumatic chipping hammer is used to cut off the surplus metal before finally finishing. It is evident that the freedom of movement of the hammer can be secured in other ways, such as a ball and socket joint of large radius, but we have found the above device more satisfactory and all that can be desired.

For riveting the side shell plating the same device is used, with one exception, and this is as follows: there is a holder provided with a T-shaped slot, the sides of which form a bearing for the T-shaped frame bar, while allowing said bar to be moved from one position to another in said slot; and a friction spring and set screw, respectively adapted to bear against the bottom of said frame bar when the latter is in position in said slot and to lock the frame bar in any desired position in said holder.

The spring dolly bar now used is made of a piece of 3-inch pipe about 12 inches long, having at one end an ordinary cast-steel handle, while at the other there is a bushing, through which a set screw holds the cup or snap. Inside the pipe there is a piece of round iron, about 6 inches long, backed up by a spiral spring.

The quality of the work done by all these machines, both inside and outside the shell, is first-class in every respect, and far superior to hand work, seeing that a rivet driven by a pneumatic hammer has to be about 12 percent longer than a rivet driven by hand, which goes to prove that the hole is better filled when the work is done by pneumatic tools, and such is the unanimous opinion of the inspectors who have been and are on duty in the American shipyards.

That this is natural appears from several considerations. The rivets are closed down more rapidly and at a much higher temperature, and, as it is always easy to bring the axis of the hammer in line with the axis of the rivet, and, in fact, natural for the men to do so, the rivet is plugged at once by the first blows of the hammer, thoroughly filling the hole throughout before the point begins to form. The tendency of hand riveters to save labor, to form the point without thorough plugging, leaving a rivet which, though looking all right and passing the tester, is liable to loosen afterwards in service from the constant jar and vibration of the hull, is, therefore, avoided. In many confined places, also, where only one man can strike, and the space for the swing of the hammer is confined to the frame spacing or less, hand rivets are very apt to be poorly driven, but it is evident that such considerations do not affect the machine, and that, if the pneumatic hammer can get to the rivet at all, it is as well put in as in the most open parts of the work.

As to the cost of pneumatic riveting, I submit the following figures, which are piece-work rates current in the States, also figures comparing them with the British piece-work hand rates. In making this comparison, I must call your attention to the fact that both day-work and piece-work rates in America are about 35 percent higher than in Great Britain. This is due chiefly to the cost of living being higher. So that the piece-work prices for pneumatic riveting in Great Britain should be one-third less than the prices paid in America.

Distribution.	No. of Rivets.	Diameter of Rivets. Inch.	Machine Rate, Each. Cents.	Hand Rate, Each. Cents.
Keel (flat)	6,217	1	2½	4½
Shell	21,628	⅞	1¾	3½
Shell margin (bilge single line)	1,122	⅞	3	4½
Longitudinals, open	24,632	¾	1¼	2¾
C. V. K. brackets	3,197	¾	1	3½
" "	.....	..	1¼	3½
" "	.....	..	1½	3½
Longitudinals under tank	664	¾.	1¾	2¾
Longitudinals, bars	2,989	¾	1¼	2¾
Tank top stiffeners	1,129	¾	2½	3½
Tank top margin	4,033	¾	1½	2¾
Tank top rider	3,209	¾	1¼	2¾
Tank top lugs	1,520	¾	1¾	3½
Tank top	4,467	¾	1¼	2¾
C. V. K. cross vertical keelson	12,723	¾	1	3
Hold stringer	1,184	¾	1½	3
Floors	123	¾	1¼	3
Floors (odd)	5	¾	2	6
C. V. K. (odd)	38	¾	2	6
Bulkheads	1,318	¾	1¼	5
"	3,051	¾	1¼	3¼
"	231	⅝	1½	2½
Total	93,480			

The foregoing was compiled from an actual test covering a period of three weeks at the Chicago plant of the American Shipbuilding Company.

Total cost of job by hand would have been	$2,986.87
Total cost of job by machine was	1,403.31
Saving of machine over hand work	$1,583.56
Average cost per rivet of hand work	3.19 cents
Average cost per rivet of machine work	1.50 "
Average saving per rivet of machine hand work.	1.69 "

Average cost of machine riveting was 47 percent of hand cost.

If the above 93,480 rivets had been driven by pneumatic tools in a vessel building in a British shipyard at piece-work rates one-third less than are paid in America, the result would be as follows:

Distribution.	No. of Rivets.	British Pneumatic. Price per 100. s. d.	British Pneumatic. Total Cost. £ s. d.	British Hand. Piece-work. s. d.	British Hand. Total Cost. £ s. d.
Keel (flat)	6,217	7 0	21 15 2	11 10	36 15 8
Shell	21,628	5 0	54 1 5	8 8	93 14 5
Tank margin	1,122	8 4	4 13 6	10 0	5 12 2
Longitudinals, open	24,632	3 6	43 2 1	8 6	104 13 9
C. V. K. brackets.	3,197	3 6	5 11 10	8 6	13 11 9
Longitudinals under tank	644	5 0	1 13 2	9 6	3 3 1
Longitudinals, bars	2,989	3 6	5 4 7	9 6	14 3 11
Tank top stiffeners	1,129	7 0	3 19 0	10 0	5 12 11
Tank top margin	4,033	4 2	8 8 0	10 6	21 3 6
Tank top lugs	1,520	5 0	3 16 0	10 0	7 12 0
Tank top rider	3,209	3 6	5 12 4	10 6	16 16 11
Tank top	4,467	3 6	7 16 4	10 6	23 8 0
C. V. K. vertical keelson	12,723	2 10	18 0 6	8 6	54 1 5
Hold stringer	1,184	4 2	2 9 4	8 6	5 0 8
Floors	123	3 6	0 4 4	8 6	0 10 5
Floors (odd)	5	5 9	0 0 4	11 6	0 0 7
C. V. K. (odd)	38	5 9	0 2 2	11 6	0 4 4
Bulkheads	3,051	4 2	6 7 1	7 0	10 13 7
			£192 17 2		£416 19 1
					192 17 2

Amount saved by machine over hand (British rates) £224 1 11

The amount that should be added to machine cost to cover interest, maintenance of plant, and operation of compressor, is about 15 percent of the gross earnings of the tools.

It is only fair to mention that, at the time the above test took place, about seven years ago, pneumatic tools were not so perfect as they are to-day, and their application to ship construction has been very much simplified. For instance, when driving bulkheads and shell it was customary to use a pneumatic holder-on, which necessitated something to act as a backing for the tool, said backing having to be built up, which added considerably to the total cost of riveting, whereas now a spring dolly bar is used, which the holder-on holds in his hands; again, the shell device for holding the riveting hammer while driving the rivet has been very considerably improved, and can be removed from one position to another on the ship in less than one-fifth the time required to remove the old device.

In conclusion, I should like to say that, while visiting the various shipyards on the Clyde, one of the most prominent shipbuilders called my attention to the fact that since commencing to use pneumatic tools they have turned out 20 percent more tonnage, from the same building berths, than they did before. So there is not only a saving in the reduced price of work done by pneumatic tools, but also a great saving in time, which is a very important item to a shipbuilding company which is limited

as to space and has not sufficient berths to accommodate all the vessels under order.

Thus it will be seen that, while pneumatic tools are still only in their infancy, there is no limit to the advantages that shipbuilders and engineers can gain by their use in connection with shipbuilding and engineering. In addition to the tools already mentioned, there are now on the market pneumatic hoists, ramners, molding machines, wood-deck calking machines, wood-deck planing machines, painting machines, and large hammers for blacksmith work.

of dealing with plates of this same weight, while a beam bending machine can handle anything up to 12 inches in size. There is a large compressor plant for generating compressed air to be used in drilling, chipping and calking, a large plate scarfing machine, multiple drilling machines, edge planing machines, a large manhole punch, capable of punching an entire manhole at one stroke up to 24 by 17 inches, besides the various smaller tools in the way of saws, hammers, etc., necessary for the operation of such a plant. The equipment includes also a 6-ton locomotive crane traveling along the side of the dock.

GENERAL VIEW OF THE DOCKYARD OF THE HALIFAX GRAVING DOCK COMPANY.

Repair Work in the Dry Dock at Halifax.

Considerable interest attaches to the photograph on this page showing the North German Lloyd steamship *Bremen* in dry dock at Halifax for repairs necessitated by a peculiar accident which occurred last fall. It will be recalled that this steamship left New York, and had proceeded about twenty-four hours on her way to Europe, when the breaking of one of the propeller shafts allowed that propeller to slip aft in such a way as to foul the other propeller, and entirely stop the ship's progress. The arrangement of the propellers was such that the diameter was slightly greater than the distance between centers of shafts, so that the propellers overlapped, and, as a result, one was necessarily placed forward of the other, and it was the shaft of the forward propeller which caused the difficulty.

As placed in the dry dock, this ship with stores and cargo represented a total weight of 16,800 tons and the draft was 25 feet 6 inches aft and 23 feet 6 inches forward. The *Bremen* has a length of 525 feet 1 inch, a beam of 60 feet 2 inches and a depth of 34 feet 8 inches, the tonnage being 11,570 gross and 7,202 net. Propulsion is by means of two four-cylinder quadruple expansion engines, with cylinder diameters 27½, 40¾, 59 and 83½ inches, and a common stroke of 53 inches. The ship was built by Schicau, at Dantzig, Germany.

The repair shops of the Halifax Graving Dock Company, Limited, are equipped with modern tools and all facilities for the performance of ship repairs. The plate bending rolls have a length of 34 feet, and are capable of handling plate up to 1½ inches in thickness. Punching and shearing machines are capable

Additional interest is lent to the photograph by the fact that in the background are seen the five ships of the British Second Cruiser Squadron, which visited New York in November. Four of these are in a group in the left background, while the *Drake* is alongside a pier, directly back of the foremast of the *Bremen*.

THE CITY LINER CITY OF GLASGOW.

The City line of steamers from Glasgow and Liverpool to India is one of the oldest shipping companies in the world. It was originated in the year in which the first Cunard steamer crossed the Atlantic, and like the Cunard Company it had its inception in Glasgow. The originators were the firm of George Smith & Sons, soft goods merchants in Glasgow, who were led into shipping through having to take over a Canadian barque of 300 tons in payment of a bad debt. They at once built two or three more, and started the City line of sailing packets to the East, and in process of time they dropped the sailers and built a fleet of steamers, which acquired and have retained first place among the tea-carriers because of their construction and management. The City fleet now consists of about twenty steamers trading regularly with freight and passengers between Glasgow, Liverpool, Calcutta, Bombay and Karachi. Although in 1903 amalgamated with the Ellerman Lines, Limited, the City line is still managed by the old firm.

From the yard of Workman, Clark & Co., Belfast, has now been launched a new steamer for the line. The *City of Glasgow*

is of about 6,400 tons, and is intended for passenger and cargo service between Liverpool and Calcutta. The arrangement of the accommodation for first-class passengers is on the bridge deck, and for second-class in the poophouse. The holds have been specially arranged for the reception of bulky cargo, with latest facilities for rapid loading and clearing. The construction of the hull and machinery was carried out under the survey of the British Corporation of Shipping to qualify for their highest

THE CITY OF GLASGOW ON HER TRIAL TRIP.

class, and with the Board of Trade requirements for a passenger steamer. On her trial cruise an average speed of 15 knots was maintained.

The *City of Glasgow* has accommodation for 136 passengers. Special attention has been given to the arrangements of the five cargo holds, to enable her to receive the largest and bulkiest items of cargo, such as boilers, locomotives and railway cars. The cargo gear consist of eleven steam winches, with suitable derricks swung from the masts, and fitted with the necessary tackle for expeditious handling of cargo.

The staterooms for the first-class passengers are commodious and well appointed, and are placed in a large house on the bridge deck, as well as on the upper deck at the forward end of the bridge space. The dining saloon is a spacious and handsome apartment which provides accommodation for over eighty diners. The wainscotting is of light unpolished oak, neatly paneled, and the furniture is to match. The saloon is lighted by large cottage windows and a large dome, and is built on the bridge deck. The pantry and other offices are conveniently arranged. A large and well ventilated nursery is provided. From the dining saloon a stairway leads to the upper bridge deckhouse, containing additional staterooms and an artistically furnished ladies' room, which is lighted by cottage windows. A piano, bookcase, writing tables, and other conveniences are provided. At the after end of the same deck is situated the smoke-room.

The staterooms for the second-class passengers are provided in the poop, as well as a dining saloon with pantry adjoining, and other necessary conveniences. On the poop deck an entrance house and smoking room are placed, approached by a stairway from the second-class alleyway. A barber's shop has also been fitted.

Rooms for officers and engineers are placed in a deckhouse at the after end of the bridge deck. The Lascar crew, seamen and firemen, are housed at the after end of the poop. Their quarters are approached by a companionway from the poop, where their native galley is situated.

THE CITY OF GLASGOW ALONGSIDE PIER.

The propelling machinery consists of a set of quadruple expansion engines, capable of developing 4500 I. H. P., and supplied with steam from four single ended boilers of the multitubular type, working under Howden's system of forced draught. The main engines have cylinders 27½, 39½, 56½, and 81 inches in diameter, with a stroke of 54 inches and a working pressure of 215 pounds to the square inch. The four boilers are 15 feet

6 inches in diameter by 12 feet long, with a total heating surface of 11,000 square feet, and 280 square feet of grate surface (39.3 to 1). The one propeller has manganese bronze blades.

The *City of Glasgow* is fitted with the newest pumping arrangements in the engine-room—Weir's pumps and evaporator, winch condenser and electric engine and dynamo (both to light the ship, including cargo clusters for working the cargo, and to drive the fans in the passengers' staterooms). She is also fitted with a refrigerator sufficient to keep all provisions fresh and in good condition in the tropics. Benjamin Taylor.

PHYSICAL LABORATORY OF THE PHILIPPINE NAUTICAL SCHOOL.

Need for an American Nautical College Stirred by the Existence of the Philippine Nautical School.

BY FRANK VAN VLECK, PH. D.

The needs of a higher nautical education for the American youth contemplating a marine career is perhaps best emphasized by the very scarcity of schools granting even the semblance of nautical instruction. If America is to sustain its waning maritime prestige, it must do it by affording occupation to the sea personnel of the present, and by far more systematic efforts to train men for the sea profession of the future. If we are to have a mercantile marine worthy of the name, we must soon begin to prepare the men for the responsibilities of new fleets The great steamship lines all recognize that the great administrative officers of the future, the managers, the captains, the chief engineers—yes, and even subordinate officers, must be educated and trained men—educated to the profession of the sea; and that the forecastle and the steerage alone will not afford the training for the most exact seamanship, nor certainly for the finer arts of commercial diplomacy, international law, rare business judgment, and the varied requirements of a general linguist.

Yet we as Americans practically do nothing to train our youth for the sea career. Our colleges turn out graduates by the thousands for almost every niche in the railroad profession, or for manufacturing life. Some paltry three or four turn out a handful of naval architects, but not one institution fits young men for the maritime profession. The great Naval Academy is not included, for this is a closed college save for the elect, and trains solely for the navy, and not in any wise for the benefit of the mercantile marine.

The ambitious young American who desires to train and educate himself for the sea profession, in a manner adequate to what all other professions and industrial life demand, simply cannot gain this education and training in America. He must either give up such hope, or go to Europe for the training, or, as thousands of other young Americans have done, stand idly by and see the freshly naturalized foreigner, trained in a European nautical school or college, gain the coveted distinction of treading the bridge in command. Even in Europe there are but few such institutions that will admit foreigners—Americans. This our own navy discovered when it was sought to train young naval constructors at the Ecole Maritime of France, or Royal Naval College of Greenwich.

As it is impossible to obtain the higher nautical education, our young American, with the love of the sea unquenched, probably then contents himself with the secondary education to be found in a state school ship, if he is fortunate to live in one of the three States of the Union which maintain these ships. If not a resident of these States—it were far better that he were—a "Filipino." Even should he be a resident of one of these States, perhaps his wiser parents object to his sea education in an atmosphere in which the public regard the school-ship as synonymous with a reformatory. For somehow the opinion of the school-ship seems not to be much in advance of the cat-o'-nine-tails period. Of course, this is unfounded. This, then, is the condition of American nautical education—none worthy of the name.

Amid this discouraging outlook, it is interesting to look across the seas to our insular possessions, and behold a nautical school in full swing, braced by the prestige of seventy years of age—a school established by the Spaniards at Manila, and taken over by the American army of occupation, and at once administered by able officers of the United States navy. Thus accidentally has our nation provided for the Filipino youth the means for a nautical education, which it has not in any equivalent provided for any of its own sons.

The very existence of this Philippine Nautical School is so little known of, that it almost seems as a discovery, consequently the accounts submitted of it, abstracted from the Reports of the Philippine Commission, may prove of more than the usual interest.

The Philippine Nautical School was established in 1830 by the Philippine Board of Commerce, and, as its name implies, its purpose is to give theoretical and practical instruction in navigation. The original home of the institution was destroyed by the earthquake of 1863, and since that time the school has suffered three changes of location. Its present location is at No. 97 Calle Santa Elena, district of Binondo, in the city of Manila. With

the change of sovereignty the school passed to American hands, and Lieutenant-Commander Cottman, Lieutenant Cooper, Lieutenant Townley, and Lieutenant-Commander Knapp, of the United States navy, were successively placed in charge. Under the administration of Lieutenant-Commander Knapp English text-books and American methods of instruction were introduced, and the school reached a very high degree of excellence. When Commander Knapp was relieved from duty in the Orient by the Navy Department, Lieutenant-Commander Glennon was detailed for duty as superintendent of the school and rendered excellent service until November 1, 1902, when he was relieved from duty. Since his relief the bureau of education has been unable to secure the services of a naval officer as superintendent. From 1903 until the end of the last school year the assistant superintendent was in charge of the school and carried on the work of theoretical instruction along the lines prescribed by his predecessors. At the beginning of the last school year Mr. C. L. Jenkins was placed in charge.

The school is well equipped with nautical instruments, and has a good telescope, tellurians, celestial and terrestrial globes, maps, charts and other supplies. It is poorly housed, however, and as soon as insular finances permit, a vessel of sufficient size will doubtless be secured as a home for the school, and for the purpose of giving the students practical instruction in seamanship. The course prescribed is four years, and is as follows:

First year: Arithmetic, algebra, plane geometry, geography, English, and seamanship.

Second year: Algebra, plane and solid geometry, plane trigonometry, physics, geography, drawing, English and seamanship.

Third year: Spherical trigonometry, physics, electricity and magnetism, physiology and hygiene, astronomy, navigation and nautical astronomy, seamanship, and English.

Fourth year: Chemistry, Philippine and United States history, navigation and nautical astronomy, English and seamanship.

To secure the proper physical development of the pupils, setting-up exercises, infantry and seamanship drills, fencing and singlestick are prescribed, and boxing, football, and baseball encouraged. The students display great proficiency in mathematics, and evince a very commendable interest in their chosen specialty. The school enrollment is 121, and the average attendance 115, or 95 percent of the enrollment.

The school opened on June 30, 1902. The number of students was 73, divided among the four classes, as follows: First class, 16; second class, 8; third class, 19; fourth class, 30. None were added to the first class, and 1 left school, leaving 15 to graduate. One entered the second class and 3 left during the school year, leaving 6 at the close of the year. Three entered the third class, and 4 left, leaving 18 at the close of the year. Ten entered the fourth class, 11 left, and 1 died, leaving 28. This gives a total of 67 students enrolled at the end of the year. The attendance was fairly good; 94.45 percent for the first class, 98.59 percent for the second class, 90.86 percent for the third class, and 92.86 percent for the fourth class. The attendance for the entire school averaged 93.27 percent.

The entering class was very poorly prepared. Some system of selection by division superintendents or governors of provinces of bright boys would remedy this. Not more than five or six boys in the school ever had any instruction by American teachers before entering the nautical school. With such a state of affairs existing it is very difficult and it might be said, almost impossible for the instructors to do good work. By good work is meant turning out good products, for results are almost the only things by which to judge a workman.

The school is well supplied with books; with other essentials not so well. A laboratory is needed to supplement the text-books in chemistry and physics. It is understood that apparatus for both has been ordered from the United States. An entire change in the text-books, from Spanish to English, has been effected, and it is hoped that the best results will follow. The Filipino is said to be deficient in reasoning power, and this is true to a great extent. Yet the results obtained in sciences have been very good. In many instances wonderful progress has been shown. It is believed that on the completion of their course in the nautical school, four of the six boys in the highest class could stand in the first third of the entering class in the scientific department of any of the universities or colleges in the United States. Their work in mathematics is superior to that of the average American entering class. The corps of instructors consist of industrious teachers, having a thorough knowledge of their subjects, and are popular with the students.

Last year there were placed about three-fourths of the students in the lower classes on the boats of the different steamship companies in the islands, for practice during the vacation months. This has proved to be a valuable adjunct to their study in the school. The steamship companies deserve thanks for their assistance. Some time in February it was recommended that the graduates be placed on the coast-guard service boats, which vessels constitute the insular navy. An appropriation was expected to be made at any time and so the boys were kept waiting. Deciding that no appropriation would be made, the old method was returned to of getting positions for the boys on the merchant boats. There were 15 students in the graduating class last March. Three of them are now mates drawing salaries of $110 Mexican per month and food. One has been offered a like inducement, but up to the present time has been unable to secure a mate's certificate by reason of his being under the minimum age of 18 years. One of them receives $70 a month and food, and 9 others are getting only their food and instructions from their captains in return for their services as mates or midshipmen. I have been assured that all will get positions as mates just as soon as they have had sufficient experience to obtain certificates.

AT DRILL ON THE PRACTICE MAST AND RIGGING.

Six boys graduated from the school one year ago last March. One is first officer on the *Buen Viaje*, plying between Manila and Singapore. He gets $175 Mexican per month and everything found. Another receives $110 and food, another $45 and food. One is on a large Japanese liner, one is a midshipman, getting his food only, and the sixth of the class is doing nothing. It is understood that his parents are wealthy, and that he will not take a minor position.

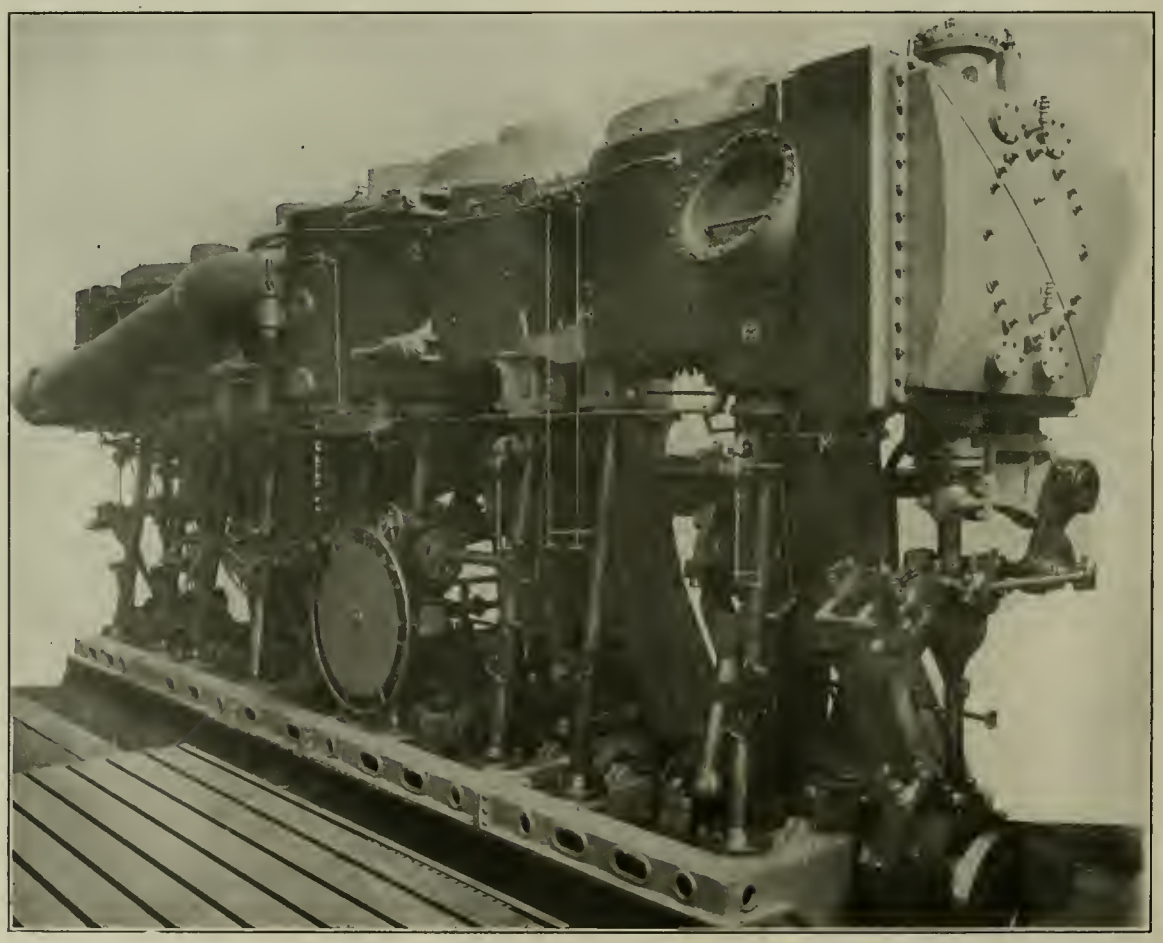
All the graduates were informed that the Commission had passed an appropriation to place 12 of them on the coast-guard service boats. The appropriation was to cover their expenses as marine cadets, the amount of the expenses not to exceed $2,000 for a period of six months. Lieutenant-Commander Helm, chief of the coast-guard service, stated that his interpretation of the ruling of the Commission was that it covered the cost of uniforms and food up to $15 gold per month for each midshipman. The latter was based on the government allowance for the officers on the coast-guard boats. But these men do not find that this sum is sufficient. It costs them from $10 to $20 Mexican per month in addition. Commander Helm and the superintendent of the nautical school decided that it would be better to leave the graduates where they are, for the present at least.

THE FIRST-CLASS ENGLISH ARMORED CRUISER BLACK PRINCE.

BY FRANK C. PERKINS.

The *Black Prince* is the first of six first class armored cruisers of the *Duke of Edinburgh* type, which are under construction, four being built in the yards of private contractors, and the remaining two at the Royal dockyard at Pembroke. The *Black Prince* was launched by the Countess of Selborn, at Canningtown, at the shipyard of the Thames Iron Works Shipbuilding and Engineering Company, Limited. She was commenced in January, 1903, and was completed and commissioned for sea in March, 1906. This is the first English war vessel that this firm has completed ready for commission, although they have always done so in the case of vessels for foreign navies.

The ship is 480 feet long between perpendiculars, with an extreme beam of 73½ feet, the depth from the outer bottom to the upper deck being 40 feet 9 inches, the draft forward 26½ feet, and the draft aft 27½ feet. The displacement is 13,660 tons, while the indicated horsepower of the machinery installed for propelling the vessel was designed to be 23,500. The designed speed was 22.33 knots. On the official trials the speed



STARBOARD MAIN ENGINE (12,000 HORSE POWER) OF NEW ARMORED CRUISER BLACK PRINCE.

The average cost of building and completing for sea the ten cruisers of the *Kent* class (English, 9,800 tons) was $3,674,450. The cost of the annual upkeep is about $82,500 for each ship for coal and sea stores, while it is estimated that the average annual cost of repairs for the first eight years will be about $27,500. These ships are very similar to the American cruisers of the *St. Louis* class, but have better speed.

Four of them visited New York last fall, as part of the Second Cruiser Squadron.

obtained was 1.32 knots in excess of her guaranteed contract speed, the rate being 23.65 knots.

The propelling machinery, which was constructed at the company's engineering department at Greenwich and Deptford (formerly John Penn & Sons), consists of two sets of inverted four-cylinder triple expansion engines, working at a pressure of 205 pounds in the high-pressure valve chest. The high-pressure cylinder measures 43½ inches in diameter, and the intermediate 69 inches, while the diameter of the two low-pressure cylinders

is 77 inches, with a stroke of 42 inches. The engines are balanced on the Yarrow-Schlick-Tweedy system, and arranged to run at a speed of 135 revolutions per minute.

There are two separate and independent condensers to each set of engines, and two independent twin air pumps arranged to pump from both condensers.

The boiler installation consists of twenty Babcock and Wilcox boilers and six cylindrical boilers, working with closed stokeholds and forced draught, the working pressure of all the boilers being 210 pounds per square inch.

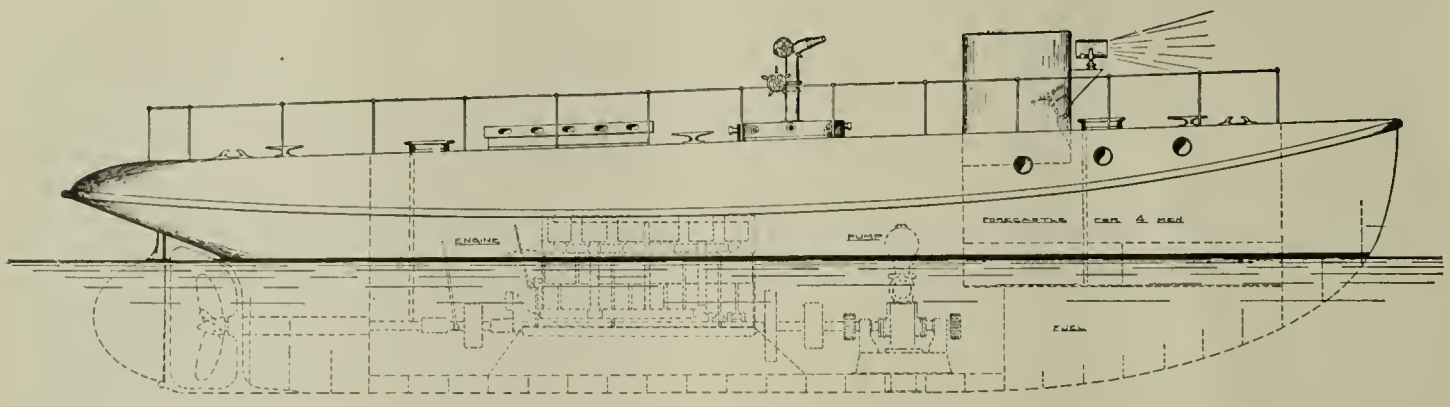
There are two complete sets of evaporating and distilling machinery, built by Caird & Rayner; and two vertical double cylinder steam steering engines and gear built by Bow McLachlan. The vessel is equipped with the latest and most complete electrical devices, all of the fans and ventilators being electrically driven, and of the Sirocco type, the motors being installed by the electrical department of the Thames Iron Works..

An electrically driven ice machine and two sets of air compressing machinery are installed, the electric current being supplied from four steam driven electric generator sets, the engines being of the Peter Brotherhood type, and the dynamos designed and constructed by Lawrence Scott. The coal, ash and boat hoists are all electrically driven. She is lighted up with about 1,400 incandescent lamps, has an electrical helm indicator, and is well served with electric bells, telephones, etc. The whole of the electrical work, with the exception of the capstan gear, is made and fitted by the firm, as well as all the ventilating and pumping work, etc. The double bottom is arranged to carry heavy oil, and is fitted with pumps, pipes and filters, to enable the boilers to use oil as fuel if necessary. The coal bunkers can carry a maximum of about 2,000 tons of coal. There are two capstans, the one forward driven by steam, and the after one electrically.

There is a complete armor belt running from stem to stern, the thickness amidships at waterline being 6 inches, and tapering at forward end to 4 inches and 3 inches aft. The citadel, which is rectangular in shape, is protected by 6 inches of armor, and carries ten 6-inch breech loading guns. Eight are broadside guns, while the two after ones can fire both athwartship and fore and aft. On the upper deck there are five 9.2-inch guns in barbettes, protected by 6-inches and 3-inches of armor, while forward on the forecastle is another 9.2-inch gun, making six in all. The foremost 9.2-inch gun and the aftermost one are situated at the middle line, so that an arc of fire of 310 degrees can be obtained. The other four 9.2-inch guns are placed at the sides of the vessel, and nearly over the ends of the citadel, and each of these commands a fire of 160 degrees. The shelter decks are well manned with 3-pounder quick firing guns, some 28 in number. There are also two Maxims and two 12-pounder 6-hundredweight guns, for boat and field use. The whole weight of armor is about 1,600 tons, exclusive of the protective decks.

ENGLISH ARMORED CRUISER BLACK PRINCE, 13,660 TONS, 23.65 KNOTS.

The battery has a protective deck covering of 1-inch steel, which is continued forward on the main deck. In addition there is the usual protective deck ¾-inches thick at the waterline running right fore and aft. The 6-inch guns are separated from each other by 2-inch splinter bulkheads. The conning tower is of 10-inch steel, provided with the usual armor tubes for carrying the leads of shafts, pipes, etc., from the shelter deck to within the armor protection. There are three 18-inch torpedo tubes, one on each side and one at the stern, all under water. One of the new features in the design is the placing of the shell rooms in the ammunition passages, close to the ammunition hoists, thus saving a deal of time in getting the shells to the guns. The 6-inch ammunition hoists have electric motors, while those to the 9.2-inch guns are worked hydraulically.



COMBINED OUTBOARD AND INBOARD PROFILE OF NEW MOTOR FIRE BOAT.

A New Motor Fire Boat.

Designed for using a gasoline engine in place of a steam engine, and for fire service in shallow waters, a new type of fire boat has been developed with a draft of 5 feet and a height above water line to top of steering shield of 8½ feet. This latter allows the boat to pass under bridges in cities intersected by rivers or canals.

As may be seen from the illustrations, the boat is propelled by a single 6-cylinder engine, which is of the Standard pattern. The engine is direct-connected to the pump by means of a clutch coupling, which permits its being disengaged at any time when the propulsion of the boat is necessary, while similar coupling at the other end permits disengaging the propeller and utilizing the entire power upon the pump. The capacity of the latter is 2,000 gallons per minute against a pressure of 150 pounds. The deck nozzle is placed at the longitudinal center of the boat, thus obviating any tendency for the reaction of the force of the stream to turn the bow or stern. The circular deck tower upon which this standing nozzle is placed has eight universal hose couplings which will fit any hose, and by means of which the streams may be carried in any direction required or into buildings. The standing nozzle and each of the eight connections may be operated independently.

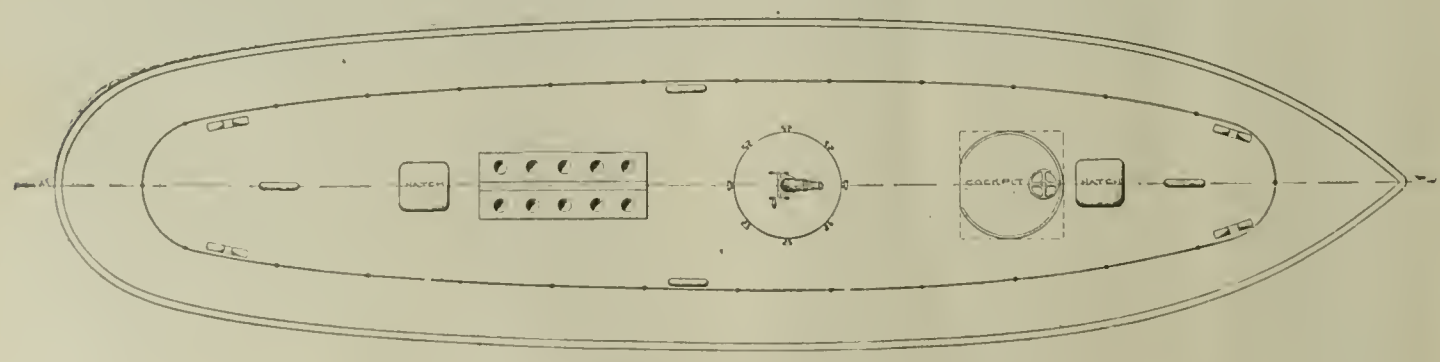
The fuel is carried in a water-jacketed tank below the water line, in order to insure against the possibility of the fumes' being ignited by the heat of any fire which might be fought. The decks are cooled by the circulation of water through the hollow hand rail shown in illustration, there being small holes two inches apart on each side to serve for the purpose of throwing a spray all over the upper part of the vessel. The very heavy construction and specially designed form combine with high propelling power to make the boat an excellent ice-breaker for winter service.

The length over all is 51 feet, with a length of 45 feet 6 inches on the water line. The molded beam is 12 feet. It is stated that the cost of building one of these boats is about one-third that necessary for the type of steam fire boat now in common use.

The keel is of the flat plate type, 18 inches wide and 15 pounds thick; the stem, which is of wrought iron, measures 5 by 1½ inches; the stern post, rudder post and arch are also of wrought iron, 5 by 2 inches, with a shoe extending 3 feet into the hull. The frames are angle bars 3 by 2½ inches by 6 pounds, spaced 18 inches, and in one length from keel to deck. Reverse frames are angles 2½ by 2½ inches by 5 pounds; they extend along tops of floor and up the frames in one piece to a point 6 inches above the bilge keelson, and are fitted on every frame. The floors are 12½ pounds thick and measure 9 inches in depth, except that under the engines and at the ends of the vessel the depth is increased to fit the requirements. They are fitted in two pieces separated by the center vertical keelson. The latter is of the same weight and depth as the floors, and is connected to the keel by double angles 3 by 3 inches by 7 pounds. A bilge keelson on each side extends all fore and aft, and consists of an angle 3 by 2½ inches by 6 pounds. Deck beams are also 3 by 2½ inches by 6 pounds, fitted in one piece, and connected to frames by triangular brackets 12½ pounds thick and 30 inches long.

The outside plating of the hull is of mild steel with strakes lap-jointed, and with liners fitted between the frames and the outside strakes. The plates are fitted in lengths of about 15 feet, all butt straps being double riveted. The weight throughout is 15 pounds, the plating being doubled at the water line for a distance of 15 feet aft from the stem. The deck plating is 10 pounds, lap-jointed.

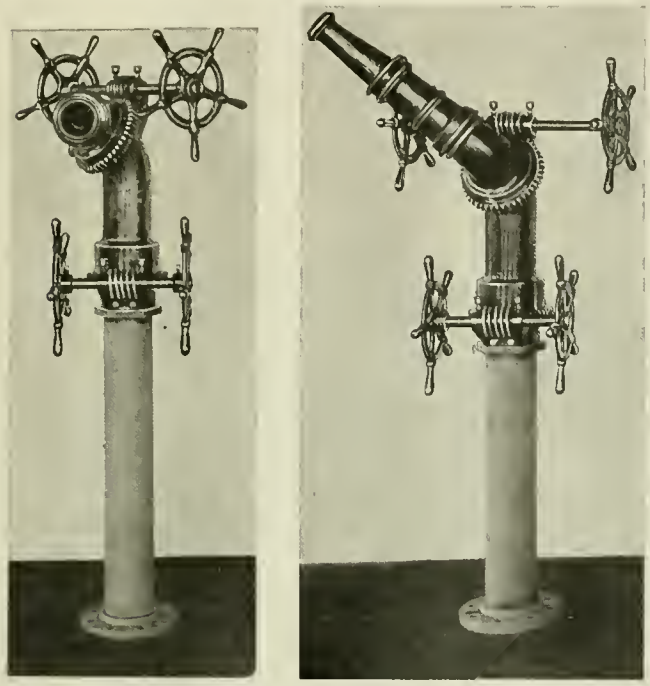
The engine foundation consists of high floors as mentioned in connection with the framing of the vessel, and is lightened by 6-inch holes. In connection with these are fitted longitudinal plates of 15-pound steel. The engine bearer angles are 3 by 3 inches by 7 pounds. The rudder has a wrought iron frame covered with double plates, the top of the stock being keyed to take the quadrant. The diameter of the stock is 4 inches. The steering cockpit has a floor 15 inches below the deck, the sides



DECK PLAN OF FIRE BOAT, SHOWING ARRANGEMENT OF NOZZLE AND FIRE TAPS.

above deck being circular and of double plating with 1½-inch air space between. The outside plating is 7½ pounds and the inside 2½ pounds, the ordinary stiffeners being used as distance pieces. The fuel tank, which has a capacity of 300 gallons, is made of 7½ pound galvanized plates, and is located forward just abaft the forefoot.

The engine, which is of the reversing type, with single acting trunk pistons, has six cylinders of 12-inch bore and 14-inch stroke. They are mounted on fourteen steel stanchions, and are provided with water jackets. The crank shaft has a diameter of 4½ inches and is of forged steel, the cranks being set 120 degrees apart and balanced. The bearings of manganese bronze are of



NOZZLES, SHOWING FLEXIBILITY OF DESIGN.

the box type. The thrust block is constructed on the bed plate of the engine, and forms a part of the after crank bearing, which is also of manganese bronze. The air pump for compressing air for starting is operated from an eccentric on the main crank shaft.

The exhaust valves are driven by a horizontal cam shaft operated by worm gearing, and are water cooled. The igniters, which are tipped with iridium spark tips, are driven positively from the main cam shaft. Lubrication from a main central tank is operated by pressure to sight feeders located on the different bearings and cylinders. Water circulation will be provided by means of a pump driven by gear on the main shaft. Water is drawn from the sea and finally discharged into the exhaust pipe, condensing the products of combustion. The entire content are then discharged overboard close to the water line, doing away with excessive noise. The propeller is three-bladed, of manganese bronze, and has a diameter of 48 inches.

The pump is of the Silsby rotary fire pattern, especially designed for strength, compactness and simplicity of operation. The working parts consist of a pair of corrugated cams which revolve together within the elliptical case. The ends of the teeth which bear against the inside of the case are fitted with metallic packing strips pressed out by springs, thus insuring a perfect vacuum and the following up of any wear which may occur. The water enters at the bottom and is discharged at the top, in a stream which is uniform and steady. All parts of the pump in contact with water are of manganese bronze. There are three discharge outlets, one being used for the main nozzle and the other two for the eight hose connections. The piping is of copper.

The revolving fire nozzle is operated by a worm gear, the shafts of which are of steel. The turret proper is made of steam brass and the operating parts of phosphor bronze. The design is sufficiently heavy to withstand all strains and pressures to be met in service. The turret leaves an unobstructed passage for the water. The joint is so constructed that water cannot accumulate, to freeze in the winter time, or to deposit sand or sediment. The gears are cut phosphor bronze. The turn table joint has a long sleeve to withstand the heavy reaction of the stream. The inlet has an inside diameter of 4 inches. Five nozzles are provided, of steam brass, 1½, 1¾, 2, 2¼ and 2½ inches in diameter.

N. C Cushing.

Large Dredger for Natal.

The new powerful sand pump dredger *Cetus*, recently launched by William Simons & Company, Limited, Renfrew, Scotland, and built to the order of the Natal government, has just completed her official steaming and dredging trials on the Clyde. The sand-pumping machinery was subjected to very exhaustive trials at Brodick Bay, when the vessel's hopper, which has a capacity of 3,000 tons, was loaded with sand well within the contract time. On completion of the pumping trials the dredger proceeded to Skelmorlie, where four runs were made on the Admiralty measured distance, when a mean speed of 10.3 knots was easily obtained, which is considerably in excess of the specified speed.

The dimensions of this large twin-screw suction pump dredger are as follows: Length, 301 feet; breadth, 47 feet, and depth

THE DREDGER CETUS.

21 feet 3 inches. She is fitted with the builders' patent sand-trapping arrangement. The centrifugal suction pumps are two in number. The large main suction pipe of the *Cetus*, capable of dredging to a depth of 46 feet, has an internal diameter of 44 inches, is fitted in a central well at the forepart of the ship, and controlled by powerful hydraulic gear fitted on the upper deck. This pipe is connected to both pumps, and is fitted with an arrangement of flexible joints for preventing damage when the vessel is working on the bar at Durban. The lower end of the suction pipe is so arranged that the vessel can plunge about in a 25-foot radius without disturbing the nozzle on the ground.

She has two sets of triple-expansion engines. Steam is supplied from three steel boilers of the Scotch type designed for 180 pounds pressure. An auxiliary condenser and separate combined air and circulating pump are provided for dealing with the exhaust steam from the auxiliary engines. The combined power of the propelling, pumping and auxiliary engines on board is about 4,000 indicated horsepower.

MOTOR BOATS.

PART XV.

BY DR. WILLIAM F. DURAND.

ENDURANCE, OR RADIUS OF ACTION.

The motor boat, in common with all engineering propositions, is necessarily a compromise between conflicting and mutually exclusive requirements. In further illustration of this general law, the relation between the endurance or radius of action and the other conditions of the problem may properly receive brief notice at this point. Endurance, expressed in time, depends, of course, on the capacity of the tanks, or in general on the total amount of fuel supply, and on the demand per hour; while the distance run depends on the time and the speed. Now, supposing a fixed fuel supply, we remember that the power required, and hence the consumption of fuel, will increase as the cube, or somewhat more rapidly than the cube, of the speed. We then have the following relations expressed in algebraic form:

Let v = speed,
H = power,
a = factor relating H to the cube of the speed, and nearly constant for any one boat,
T = total fuel supply,
F = amount required for a given distance,
r = any given distance or radius of action,
h = fuel demand per horsepower per hour,
B = fuel demand per hour,
t = endurance in hours.

Then $B = h\ H$

and $H = a\ v^3$ (nearly)

Hence $B = h\ a\ v^3$ (nearly)

$$t = \frac{T}{B} = \frac{T}{h\ a\ v^3} \text{ (nearly)}$$

$$r = t\ v = \frac{T}{h\ a\ v^2} \text{ (nearly)} \quad \ldots\ldots (1)$$

$$F = B\ t = \frac{B\ r}{v} = h\ a\ r\ v^2 \text{ (nearly)} \quad \ldots\ldots (2)$$

According to (1), the radius of action will decrease as the square of the rate of speed increases. That is, to double the speed will divide by 4 the distance which can be run on a given fuel supply; to increase the speed by 50 percent will divide the distance by 2.25, etc.; while on the other hand, to halve the speed would multiply the distance by 4, etc.

Likewise, equation (2) indicates that, for varying speeds, the total consumption of fuel for a given distance r will increase with the square of the speed, at least over the range for which h and a remain sensibly constant. This means that to double the speed will quadruple the fuel expense for a given distance to be run, with proportional increase or decrease in other cases.

These various relations hold approximately over a fairly wide range of speed, and indicate forcibly the excessive price which must always be paid for high speeds. Below a certain speed, of course, the boat cannot be efficiently operated at all, and at extreme low speeds the increase in the cost of power per unit, as denoted by the factor h, will begin to augment to such an extent that the cost in fuel for a given distance will begin again to increase. The point at which the fuel for a given distance is the least is known as the "most economical speed." For gasoline motor boats, such speed is usually lower than any speed at which the boat would be usually operated, and for moderate fluctuations on either side of the normal speed, the general relations as given above may be accepted as sufficiently accurate for general purposes.

These somewhat surprising results may perhaps be more clearly seen to have a rational basis, by considering that, in accordance with the indications of the formula, the consumption for a double speed will be for eight times the power, or eight times as much *per hour*, and for one-half the time, thus resulting in $8 \times \frac{1}{2}$ or four times the consumption for a given distance. Similarly, for endurance or radius of action, with doubled speed, the distance will be twice as great per hour, but the fuel expense eight times as great per hour, and hence the time with a fixed amount of fuel is one-eighth. Hence we have double speed for one-eighth the time or $2 \times \frac{1}{8} =$ one-fourth the distance.

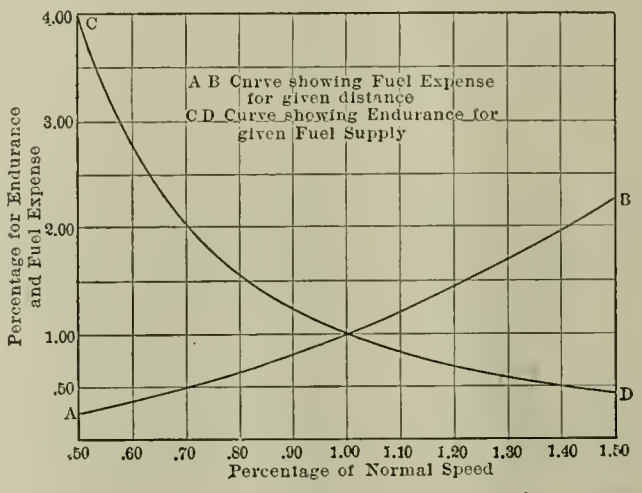


FIG. 62.

In Fig. 62 the indications of these formulæ are shown graphically for a range of speed from 50 percent of whatever may be taken as a standard or normal speed, to 50 percent above such speed.

STABILITY WHEN UNDER WAY AT HIGH SPEED.

The characteristics of the boat which favor stability have been briefly referred to under the head of design. When the boat is under way, it is readily seen that she is subject to a torque or heeling moment exactly equal to the turning moment of the engine. This follows from the general fact that action and reaction are equal in amount and opposite in direction, and hence that if the engine tends to turn the shaft in its bearings carried on the boat as a foundation, so is there an equal tendency to turn the boat about the shaft as an axis or spindle, and in the direction opposite to that of shaft rotation. This turning or heeling moment in motor boats at high speed may be sufficient to represent the equivalent of several hundred pounds placed on the gunwale, and the result may well be a decided list in the direction opposite to that in which the propeller is turning. To compute the weight on the gunwale, equivalent to the turning moment of the engine, we may proceed as follows:

Let H = power developed by engine,
N = revolutions per minute,
M = turning moment,
B = beam of boat in feet,
W = equivalent weight at gunwale in pounds.

Then $$M = \frac{33{,}000\ H}{2\ \pi\ N} = \frac{B\ W}{2}$$

or $$W = \frac{33{,}000\ H}{\pi\ B\ N}$$

Thus, for illustration, let $H = 120$, $N = 800$ and $B = 5$.

Then $W = (33{,}000 \times 120) \div (3.1416 \times 5 \times 800) = 317$ pounds.

Such a heeling moment may enter as a serious factor into the question of stability, and may reduce to an uncomfortably low margin what might be otherwise a reasonably abundant provision. The result may be to render such boats in a seaway uncomfortably cranky, and for specially high speeds the question of a large margin of stability is one which should receive due consideration. If the torque were uniform in value, it might be possible to counterbalance its influence by setting the machinery off the center line on the side toward which the crank turns when

passing its top center. Unfortunately, however, the torque varies with the power, and such an arrangement would leave the boat on an uneven keel when at rest or under low speed. It may at least be remembered, however, that the boat will tend to heel opposite to the direction of the rotation of the propeller, and shifting ballast may be provided, or, if there is any tendency toward inequality in the disposition of the weights of the machinery and equipment, the over balance should be so adjusted as to counterbalance as far as may be the effect of the turning moment; that is, the excess weight should come on the side toward which the crank turns when passing the top center.

REACTION OF PROPELLER ON RUDDER.

The somewhat irregular action of the blades of the screw propeller working in the disturbed water about the stern of the boat tends to develop a force deviating the boat from her course. To control this deviation in the case of small, high-speed boats, extra large rudder area should be provided. This deviating force due to the propeller is the result of several components, some of them opposite in character, and the resultant itself may partake of the character of one component or the other, depending on which influence is paramount.

So far as the following wake is concerned its value is the largest near the surface, and it will thus give rise to an increased value of the slip while the blade is on its upper quadrant, and with a right hand propeller it is seen that this would develop a force tending to throw the stern to port. On the other hand, in small, high-speed boats in particular, the propeller blades are likely to be near the surface of the water while on their upper quadrant, and working in water less solid or continuous than for the lower blades. So far as this condition may affect the result, the extra resistance to the motion of the blades will be while on their lower quadrant, and this will develop a force tending, with right hand rotation, to throw the stern to starboard.

With large ships having the conventional form of stern, the former influence as a rule will predominate, and the stern will swing to port with a right hand propeller, while with small boats with the torpedo boat stern, the wake is less pronounced, and the latter influence is the more likely to predominate, throwing the stern to starboard with a right hand propeller. In any case, the provision of rudder area should be generous, and experience will soon indicate the position of the helm for a steady course.

The Armored Cruiser Jules Ferry.

The *Jules Ferry* is the second cruiser of the *Leon Gambetta* class, and has the following particulars: a length on the load water line of 515 feet 1 inch; a beam of 70 feet 1 inch, and a mean draft of 26 feet 10 inches. The corresponding displacement is 12,606 tons. The coal capacity at normal draft is 1,400 tons, and the total bunker capacity is 2,100 tons, besides 100 tons of liquid fuel.

There are three sets of engines, four-cylinder, triple expansion type, operated by steam from du Temple-Guyot boilers (small torpedo tube boiler type).

The interesting features of the trials were:

2 hours with four boilers, 8,500 horsepower, and 16 knots.
6 hours with all boilers, 17,000 horsepower and 19 knots.
24 hours with all boilers, 16,508 horsepower and 18.5 knots.
4 hours with full power, 29,200 horsepower and 22.48 knots.

The coal consumption on six-hour trial was 650 grams (1,433 pounds) per horsepower-hour; on the 24-hour trial it was 744 grams (1.64 pounds); and on the four-hour trial 800 grams (1.764 pounds) per unit of power per hour.

FRENCH ARMORED CRUISER JULES FERRY AT FULL SPEED ON MEASURED MILE TRIAL TRIP.

The cruiser is shown running on the measured mile off Brest, where there is much deeper water than off Cherbourg. The *Leon Gambetta* having made off Brest an average speed of 23.46 knots, it was hoped the *Jules Ferry* could get the same speed.

The battery consists of four 7.7-inch guns in turrets, fore and aft, and sixteen 6.4-inch guns, twelve in turrets on the spar-deck and four in casemates; besides twenty-two 3-pounder guns; there are also five torpedo tubes. J. Peltier.

Oversea Trade of the United States.

	In American Vessels.	In Foreign Vessels.	Percent American Vessels.
1860	$507,247,757	$255,040,793	66.5
1870	352,969,401	638,927,488	35.6
1875	314,257,792	884,788,517	26.2
1880	258,346,577	1,224,265,434	17.4
1885	194,865,743	1,079,518,566	15.3
1890	202,451,086	1,371,116,744	12.9
1895	170,507,196	1,285,896,192	11.7
1900	195,084,192	1,894,444,424	9.3
1905	290,607,946	2,103,201,462	12.1

—*Marine Journal.*

The White Star Liner Adriatic.

As already announced, the *Adriatic* is about 726 feet long, 75 feet beam and about 50 feet deep. Her gross tonnage will be about 24,000 and her displacement will exceed 40,000 tons.

A noteworthy element of the vessel, besides her size, is that bottom will hold several thousand tons of water, and the powerful pumps with which the ship will be equipped will enable these spaces to be filled or emptied of water in a very short time.

The *Adriatic* is an exceptionally strong structure. She has

PROMENADE DECK, SHOWING GANTRY CRANE CARRYING TWO SIX-TON HYDRAULIC RIVETERS.

of safety. In addition to the general strength of the structure, the double bottom, extending the whole length of the ship, is a special element of both strength and safety. This double bottom is 5 feet 1 inch deep, except under the engines, where it is 5 feet 10 inches, to give greater rigidity in the neighborhood of the machinery; and besides securing the safety of the vessel, if she should take the ground, it also provides an economical means of carrying ballast. The tanks or cells of the double bottom will hold several thousand tons of water, and the powerful pumps with which the ship will be equipped will enable these spaces to be filled or emptied of water in a very short time.

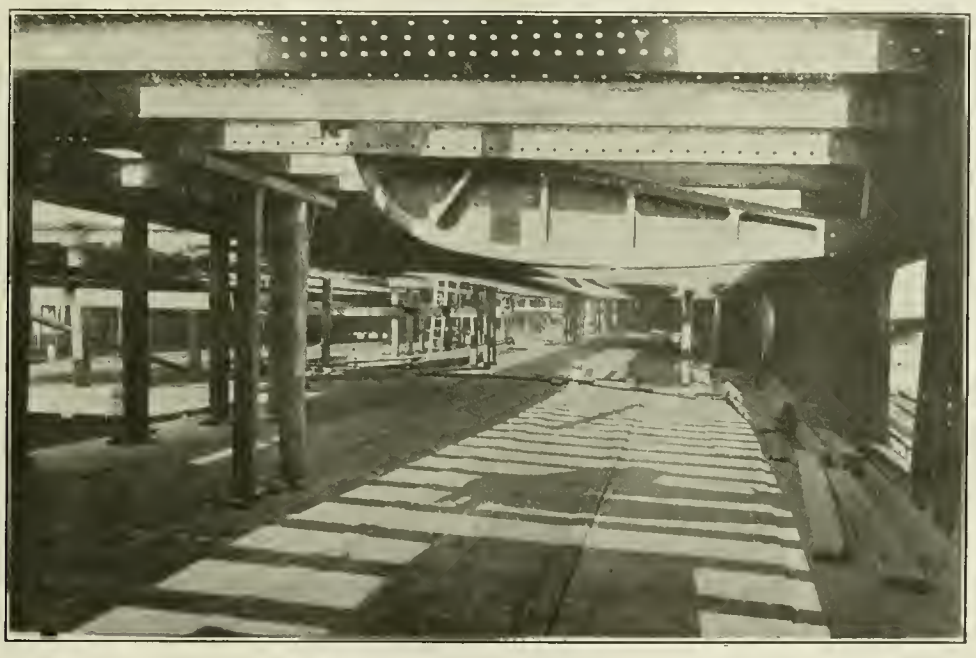
The *Adriatic* is an exceptionally strong structure. She has nine steel decks. Her frames are composed of steel channel bars, and she has eleven watertight bulkheads, subdividing the vessel into twelve watertight compartments. Many of the shell plates are over 30 feet long and 5 feet wide, and weigh between 3 and 4 tons. A large amount of the riveting throughout the hull has been done by hydraulic machines, the full headed rivets thus driven affording visible evidence of strength, as well as of the quality of the workmanship.

ON UPPER DECK, SHOWING CHANNEL BRIDGE DECK BEAMS AND HEAVILY RIVETED STRINGER PLATE.

The arrangements for cargo will be very complete, there being seven cargo holds, two 'tween deck holds insulated, and two holds fitted as deep tanks. The great feature of the vessel will, however, be the passenger accommodation, the *Adriatic* being capable of carrying about 3,000 passengers, besides officers, engineers and crew amounting to over 400.

The accommodation will be in the usual luxurious style for first class, for whom a large number of separate and distinct suites of apartments are provided, consisting of stateroom, sitting room, bathroom, etc., and full advantage of the huge dimensions of the vessel will be taken in the size and location of the dining saloons, libraries, smoking rooms, etc., and in providing promenade space for first, second and third class passengers. Throughout the whole of the living spaces the three essentials to health and comfort, viz., roominess, ventilation and light, will be in evidence.

The cables and anchors are of gigantic size, the cables being 3⅜ inches diameter, and weighing about 90 tons, while the anchors weigh about 8 tons each. The total number of steel plates in the ship will be close on 20,000, and the rivets nearly 2½ millions in number. The ship is building by Harland and Wolff, of Belfast, Ireland.



ON UPPER DECK OF ADRIATIC, SHOWING HYDRAULIC RIVETER IN POSITION.

Lloyd's Shipbuilding Returns.

Lloyd's Register of Shipping reports under construction on June 30, 1906, in the United Kingdom, a total of 569 merchant vessels of an aggregate of 1,409,456 gross tons, or an average of 2,477, as compared with 472 vessels, of 1,301,457 gross tons, for the corresponding date of the previous year. Of the total at present under construction all but about 1 percent are placed under the heading of steel vessels propelled by steam, the tonnage under this classification being 1,395,294. The present total is within about 4,000 tons of the total reached in 1901, which was the highest on record.

The warships under construction on the same date include 6 battleships and 9 armored cruisers, 17 destroyers and 13 submarines for the British navy, and 3 cruisers and 4 destroyers for other owners. The British total for the 45 ships is 246,595 tons displacement, or an average of 5,480, while the foreign total is 23,020 tons, or an average of 3,289 tons. The grand total is thus 269,615 tons.

Returns for merchant shipbuilding in other countries include figures for France, in which 32,628 tons are under construction; for Germany, with 269,238 tons; for Holland, with 60,661 tons; for Italy, with 80,923 tons; for Japan, with 44,838 tons; for Norway, with 30,483 tons; and for the United States, with 124,237 tons. The figures for the United States do not include the Great Lakes.

TECHNICAL PUBLICATION.

The Naval Pocketbook. Edited by Geoffrey S. L. Clowes. Size, 3½ by 5 inches. Pages, 965; numerous illustrations. 1906, London, W. Thacker & Company, 2 Creed Lane, E. C. Price, 7/6 net.

Since the death of Sir William Laird Clowes, which occurred last year, his son has taken up the preparation of the annual book on the navies of the world, and the volume for 1906 has appeared as usual without any break in the continuity of the series. This work is very complete in its scope, giving lists and particulars of all the warships in service or building for the different navies, and giving in addition, in the rear, outboard profiles and deck plans of nearly all of the important ships of the several fleets. The lists include not only ships valuable for war purposes, but also all other ships owned and controlled by the naval and military authorities of the different powers, and aims to include every vessel of any description which would be liable to give any sort of service, however humble, in connection with military operations. The list of destroyers and torpedo boats is also made complete, the total number included in these lists being over two thousand vessels.

In addition to the list of ships, etc., are given quite complete tables of heavy and light artillery used in the naval services of different powers, the particulars including size, weight and length of gun, weight of projectile and powder charge, and the velocity and energy exerted at the muzzle. There is also a chapter covering torpedoes of various descriptions, and a very important chapter giving particulars of all the dry docks, both naval and mercantile, to be found all over the world. These docks are arranged in geographical order following in each case directly along the coast line from one border of one of the great divisions of the earth to the next. There are also a number of conversion tables between metric and English units, and trial trip tables giving the speeds corresponding with definite measured periods of time on the mile.

INTERNATIONAL MARINE ENGINEERING

Published Monthly at

17 Battery Place - - NEW YORK

By MARINE ENGINEERING, INCORPORATED

H. L. ALDRICH, President and Treasurer

8 Finsbury Square - - London, E. C.

E. J. P. BENN, Director and Publisher

PROF. W. F. DURAND, Advisory Editor

SIDNEY GRAVES KOON, Editor

GEORGE SLATE

Vice-President and New York Representative

Branch Offices { Philadelphia, Pa., Machinery Dept., the Bourse, S. W. Anness.
Boston, Mass., 170 Summer St., S. I. Carpenter.
Chicago, 1414 Manhattan Bldg., Howard S. Moss.
Midlands, 2 Sandhurst Road, Moseley, E. E. Starke.

TERMS OF SUBSCRIPTION

	Per Year	Per Copy
United States, Canada and Mexico	$2.00	20 cents
Great Britain and Ireland	10/6	1/
Other countries in the Postal Union	10/6	1/

Entered at New York Post Office as second-class matter.
Copyright, 1906, by Marine Engineering, Inc., New York.
International Marine Engineering is registered in the United States Patent Office.
Copyright in Great Britain: entered at Stationers' Hall, London.

Notice to Advertisers.

Changes to be made in copy, or in orders for advertisements, must be in our hands not later than the 5th of the month, to insure the carrying out of such instructions in the issue of the month following. If proof is to be submitted, copy must be in our hands not later than the 1st of the month.

The edition of this issue comprises 6,000 copies. We have no free list, accept no return copies and issue only enough to supply the regular demand.

The Development of the United States Navy.

It has been well said that the strength of a naval force lies in the strength of its battleships. Cruisers and small craft have a distinct value in naval operations, but when it comes to striking a decisive blow, to meeting and destroying the force of an adversary on the high sea, the battleship is supreme, and its place cannot be taken with any degree of success by any other class of ship. It is exactly along this line that the development of the United States navy has made its greatest strides since the time of the war with Spain.

There were in service in the United States navy at the time of that war only four first-class battleships, the aggregate displacement of which was 42,210 tons. These ships were the *Indiana, Massachusetts, Oregon* and *Iowa,* and for their day they were probably more powerful than any other battleships afloat, of anything like the same displacement. There were at that time under construction five more battleships, of an aggregate of 57,696 tons displacement, which have since been passed into service, and during the opening days of the war three ships larger than the preceding, being of 12,500 tons each, were authorized. The last of these three, the *Ohio,* received her first commission in October, 1904. The twelve ships in service on that date displaced a total of 137,406 tons, and represented by a large margin the most powerful fighting force which the United States had ever had under its flag.

During the twenty odd months which have elapsed since that time, however, the additions have been of such a notable character, so far as individual and collective power is concerned, that the effective fighting force of the fleet has been well nigh doubled,and, with the completion of three ships now almost ready for service, there is no question that the force will be considerably more than twice as powerful as was the case in the fall of 1904. Of the additions since that date, three are of about 15,000 tons each, and one of 16,000 tons; while two of the former and another of the latter are in such a state of forwardness that if necessary they could be called upon for service within the course of a very few weeks. This group of seven ships comprises an aggregate of 106,740 tons displacement, or an average of 15,250 each, and in point of view of battery power, protection and speed, the ships are without rivals in any naval service in the world. It is true that a number of ships have been planned, both for our own service and for others, which will exceed in military capacity any one of the group above mentioned, and one of these ships has been launched in England, but none of them is in service, and none will be in service for a number of months. As things stand today, therefore, the latest group of ships added to the United States navy are without rivals in power.

This fact will be realized when one compares the gun fire possibilities of these ships, as shown by diagrams on page 256 of our July issue with those of ships of other powers, notably the *Lord Nelson* of the English navy. It is needless to state that the two classes of American ships referred to are represented by the *Virginia* and the *Connecticut.*

The entire group of nineteen battleships comprised within the above category has an aggregate displacement of 244,146 tons, or an average of 12,850. Of this list, fifteen ships with an aggregate of 201,936 tons, or five-sixths of the total, have been completed during the past six or seven years.

New Mammoth Battleship.

Meager reports are at hand covering the features of a battleship designed by Col. Cuniberti of the Italian navy, and said to be now under construction for that navy. This ship is expected to prove a decided advance upon the British *Dreadnought,* partly by virtue of the arrangement of mounting the guns, and partly because of the fact that the guns individually are of greater caliber and much greater power.

From information at hand it appears that the main battery is to consists of four guns of a caliber of 34 centimeters (13.4 inches) each, mounted in pairs in eight turrets. Two of these turrets are forward and aft upon the center line, in accordance with what has been for a long time common practice in warship construction. The other two turrets are mounted, one on either beam, and one of these turrets is considerably forward of the other. The superstructure has been cut away in such a manner as to permit each turret at the beam to train its guns upon the other beam across the center line of the ship, and to cover something of an angle or range of fire on that off side. This arrangement, so far as these two particular turrets are concerned, was adopted twenty years ago in the United States navy, in the designs which resulted in the construction of the two old battleships *Texas* and *Maine,* the bones of the latter of which are now in Havana Harbor. This arrangement of turrets was what was known technically as mounting the guns *en echelon,* which had an advantage, in that it permitted the concentration on either broadside of all the guns of the primary battery, without the coincident disadvantage of cutting away the freeboard at the ends of the ship, as is to a certain extent necessitated by the present method of mounting guns. A disadvantage arises from the great stress occasioned upon the decks on the off side, by the discharge of such heavy ordnance immediately above them, and also from the very restricted arc of fire obtainable on that off side. When used in conjunction with guns on the center line forward and aft, however, it forms a very interesting solution of the general problem of obtaining on a given weight a maximum concentration of broadside fire.

Information is not at hand as to the ballistics of the weapons to be fitted, but as they are entirely new, it is safe to presume that the muzzle velocity will be high, and that, as compared with the 12-inch gun now in such common use, the muzzle energy may be expected to be about proportional to the weights of shells. As the shell of this gun will be of 1,250 pounds, compared with 850 in the 12-inch guns, this means an addition of nearly 50 percent in energy at the muzzle, and, due to the well-known fact that heavy shells retain velocity to a much better degree than do lighter ones, the discrepancy in striking energy at any battle range now considered probable will be decidedly greater.

The 12-inch gun in the United States navy has a service muzzle velocity of 2,800 feet per second, with a corresponding muzzle energy of 46.246 foot tons. On the same basis of velocity, the new guns of the Italian battleship would have a muzzle energy of 68,000 foot tons. At a range of three miles the remaining velocity of the 12-inch gun is 1,967 feet per second, and the energy 22,791 foot tons. With the heavier gun the remaining velocity at three miles is 2,075 foot seconds, and the energy 37,309 foot tons.

An examination of the plans shows that the Italian will be able to bring to bear on a broadside eight guns, discharging an aggregate of 10,000 pounds of metal at once, as against eight guns, with 6,800 pounds of metal, on the *Michigan.* Forward, the Italian can theoretically project at one discharge 7,500 pounds, though probably 5,000 pounds, representing four shells, is all that could safely be counted upon in practice. Against this, the American can fire 3,400 pounds. It is seen that the advantage is due entirely to the use of the heavier guns.

As far back as 1877 the Italian navy took the lead in the introduction of ships of great displacement and high speed, and carrying remarkably powerful batteries. The first two ships with the mammoth guns adopted by the Italians at that time were the *Duilio* and *Dandolo,* each of which carried four 45-centimeter (17.7-inch) muzzle loading guns mounted in pairs on two turntables, each within a barbette. These barbettes were placed *en echelon,* as is the case with two of the turrets in the new ship. Since that time, improvements in materials of construction have led to a decrease in the size of the heaviest guns used, in spite of a continuous increase in the size of ship upon which they were mounted. The step next after the 17.7-inch gun called for a gun of the same caliber as that now introduced for the new ship. This same size was adopted by France and the corresponding size, 13.5-inch, for England; while the United States, in 1892, followed with the 13-inch guns of the *Oregon* class. Further improvements in construction, accompanied by enormous improvements in the ballistic qualities of powders used, resulted in a discarding of these cumbersome weapons for guns of a maximum of 12 inches in caliber, and with considerably greater length, proportionally, than their huge predecessors. Such were the improvements that the present United States 12-inch gun, which was adopted in 1902, has a very decided advantage over the 13-inch guns of the previous regime, as is evidenced by a comparison between the above mentioned energy of the former, with an energy of 33,627 foot tons developed by the latter. The energy per ton of gun is 889 for the 12-inch and 556 for the 13-inch.

There has been no recent disposition to go below 12 inches in caliber, but as yet this size has been considered as amply sufficient for all destructive purposes. It has been so designed and mounted as to be easily manipulated, and breech blocks have been fitted for rapid loading, so that some of the latest results show a rate of fire equal to fifteen times as great as was possible with the older and clumsier pieces of ordnance. There seems to be no adequate reason for reverting to the heavier type, with the necessarily heavier ammunition, heavier fittngs and mountings, and slower rate of operation. The design looks very well on paper, but it is more than likely that it would prove very cumbersome in practice.

ABSTRACT FROM RULES AND REGULATIONS OF BUREAU VERITAS.

EDITION OF 1905.

ARRANGED BY HARRISON S. TAFT.

PART V.

28. Sluice Valves—Ventilators—Freeing Ports.

1. Sluice Valves, Etc.

a. No cock or sluice valve will be allowed on the forward collision bulkhead. When fitted to other bulkheads they are to be so arranged as to work from the upper deck or in the machinery space.

b. A sounding pipe, extending to the upper deck, must be fitted to each watertight compartment. There shall also be a sounding pipe in each wing in double bottom vessels with or without a well. Two such pipes are to be fitted in compartments with but little dead rise to the floors. Doubling plates are to be fitted under all sounding pipes.

c. Suitable air pipes must be fitted to each watertight-ballast tank, extending to upper deck.

d. All lead pipes connecting with the sea are to have cocks or valves at the shell plating. All soil pipes are to be secured to the shell by metal elbows fitted with storm valves.

2. Scuppers and Freeing Ports.

There shall be a proper number of scuppers fitted to all decks, those fitted to the lower decks leading into the bilges by pipes protected by wood coverings. Drain pipes leading into the bilges are also to be fitted to any part of a ship likely to retain water.

TABLE 8.—AREA OF FREEING PORTS.

Length of Bulwarks in the well. Feet	30	35	40	45	50	55	60
Total area of freeing ports on each side. Sq. ft.	9.5	10	10.5	11	11.5	12	12.5

65 feet and above: 1 sq. ft. for each 5 feet length of Bulwarks

3. Ventilators.

They are to be made thoroughly watertight. They are to stand from 2 to 3 feet above the deck and are to be of the same thickness as the side plating of the deck house, but not to be less than ¼ inch in thickness.

4. Cement, Etc.

The bottom plating, frames and inside riveting to the middle of the turn of the bilge and in the peaks, should be coated with some suitable protective cement, worked to the level of the limber holes. All other iron work should have three coats of good oil paint. It is recommended that the inside of water ballast tanks be given a cement wash instead of being painted, the bottom frames and rivets being treated as above stated. The tank top should be cemented in the engine and boiler rooms.

29. Wood Decking, Etc.

1. Said decks are to be of teak or selected pine, fastened to the beams by galvanized screw bolts and nuts, said bolts being dowelled watertight.

2. The deck planking of all second and exposed decks is not to exceed 6 inches in width. The deck planking of orlop decks is to be double fastened if over 7 inches in width.

3. When a wood deck is fitted over a metal deck it can be ½ inch less in thickness than otherwise, but not to be less than 2½ inches thick in any one place. Such wooden decks must also be bolted to the deck plating between the beams. See also sections 33, 34 and 35.

4. Teak decks may be ½ inch less in thickness than required for other woods, but must be not less than 2 inches thick in any place.

5. Butts of deck planks must not come in the same frame space oftener than every fourth plank.

6. Wooden decks are to be calked watertight with at least three threads of oakum.

7. Wooden decks are to be renewed when worn to ¾ of their original thickness.

8. Ceilings. The bottom of a vessel is to be close ceiled in wood up to the upper turn of the bilge. From said upper bilge to the upper deck the sides of the holds are to be sparred ceiled. The ceiling is to be secured to the reverse frames by bolts and nuts. The ceiling on top of floors and tank top is to be laid in hatches, that on top of the tank top being laid on bearers. Through bolts connecting the bearers on top of the tank top to said tank top plating will not be allowed. The side ceiling of holds in vessels engaged in the coal trade can be omitted.

30. Steering Gear and Rudders.

1. The diameter of rudder stocks for high speed steamers is to be determined by the following formula:

$$d = .18 \sqrt[3]{a \times b^2 \times v^2}$$

where d = diameter of stock in inches: a = immersed depth of the rudder in feet: b = the extreme breadth of the rudder in feet: v = the speed in knots. But said diameter must not be less than the tabular diameter.

2. The rudder pintles should not be more than 4 to 5½ feet apart top to top. It is advisable to make them independent of the frame. The stock can be made in one piece with the frame or secured to it by bolts with a key, there being a large coupling on both stock and frame. It should be turned from below the rudder trunk to the head. There shall be a stuffing box or otherwise fitted at the deck.

3. Side Plated Rudders. The rudder frame main piece should taper from the stock to the heel where its sectional area can be made 45 percent that of the stock. The arms or stays are to be spaced 4 to 5½ feet apart. The after part of the frame may taper towards its middle from where it joins the head and the heel,

but it should not be less than 1 to 1½ inches in thickness. Its breadth should be about 60 percent of the stock's diameter with a minimum size of 3 inches. The side plates are to be ⅛ inch thicker than the lower part of bulkhead plating.

4. Single Plate Rudders. The main piece shall be made with a taper from stock to heel where its sectional area may be 55 percent that of the stock. There shall be a groove on the after side of said stock to take the rudder plate. The thickness of said plate should be ⅛ the diameter of the rudder stock, with an allowable range of thickness from ⅝ to 1⅜ inches. There shall be an arm at each pintle, located alternately on opposite sides of the rudder plate. The sectional area of each arm at its connection to the main frame shall be 50 percent that of the stock, with a gradual taper toward its end, where it can be of the same thickness as the plate. When an arm is located between the pintles in addition to those at the pintles, and the arms are placed alternately on each side of the plate, their area at the main piece may be but 35 percent that of the rudder stock, with the thickness of the rudder plate 1-9 the diameter of the stock, with ½ inch and 1⅛ inch as the two limits for thickness.

5. Balanced Rudders. The diameter of the rudder stock at the head may be 85 percent of the diameter otherwise required, if the rudder area forward of the axis is about ⅓ the total area. With such rudders the diameter at the neck bearing shall be 20 percent larger, the diameter at the heel being 30 percent less than the diameter of the stock required for a non-balanced rudder. The depth of the heel bearing is to be not less than its own diameter, that of the neck bearing being 1½ times its diameter. The main piece should taper from the neck towards the heel and from the neck to the stock. This data is for rudders which are in depth between the neck and heel bearing about 24 times the tabular diameter of the rudder stock. Spacing and size of stays, including thickness of plate, is to be as for a single or a side plate rudder respectively as above.

6. All rudders should be so arranged that they can be unshipped when the vessel is afloat.

7. The stops should be fitted to stop the rudder at from 35° to 40° from center line. Said stops should be fitted on the deck besides being fitted on the rudder itself.

8. Steering Gear. The radius of the quadrant shall be determined by the formula: $R = 6\,(D + 2)$: the diameter of the steering chains by the formula: $d = \frac{D+1}{8}$, and of the steering rod by: $d_1 = \frac{D+1}{6}$: where in $D =$ diameter of rudder head in inches: $R =$ radius of quadrant feet: $d =$ diameter of steering chains in inches; and $d_1 =$ diameter of steering rods in inches.

The eye should equal in depth the diameter of the rudder head; its outside diameter being 1.8 times the diameter of said head.

31. Life Boats.

Gross Tonnage	Under 100	100 under 400	Over 400
No. of Boats	1	2	At least 3

All vessels to have a boat capable of carrying a stream anchor.

32. One, Two, and Three Deck Vessels.

1. Such vessels include all those having their upper deck running from stem to stern without interruption and not otherwise belonging to the spar or awning deck type.

2. Depth for regulating scantling to be found as given in section No. 1. The reduction of 85 and 75 percent respectively will also be allowed in three deck steam vessels where hold beams are dispensed with if web frames or deep framing is substituted for same.

3. Two and three deck vessels of 22 or more feet in depth to the upper deck must have their upper and second deck entirely plated over or covered with wood.

4. When a complete or partial steel deck is required it is to be fitted to the upper deck. When one complete and one partial steel deck are fitted the former is to be laid on the upper deck, the latter on the second deck.

5. When deck houses of other than limited dimensions are erected on the upper deck of three deck vessels partial bulkheads or otherwise must be fitted between decks.

33. Spar Deck Vessels.

1. Including vessels carrying light cargo in the upper 'tween-decks. Said vessels having only light deck erections, and at least two laid decks.

2. In no case is the athwartship number to be less than 45 or the longitudinal number less than 77.500.

3. If deck houses of other than limited size are erected on the spar deck partial bulkheads or otherwise must be fitted between decks. See also table 2.

4. The upper and second decks must be permanently plated over or covered with wood. A reduction of ½ inch from tabular thickness will be allowed on the deck planks of said decks, but no planking under 3 inches will be allowed when no plated deck is fitted.

5. When a complete or partial deck is required it must be worked on the upper deck. With one complete and one partial deck, the complete deck must be worked on the upper deck, and the partial deck on the deck immediately under it.

6. Depth for determining deck stringers to be measured to upper deck.

7. In vessels whose depth is more than 1-14 of length the deck stringers and ties of the main deck can be ⅛ inch less in thickness than the tabular thickness, but not to be under 11-32 inch thick amidships and 5-16 at ends.

34. Awning Deck Vessels.

1. In these vessels a light deck is fitted over the second deck from forward to aft to shelter passengers or light cargo. If the top sides between the awning deck and the second deck are left open for a certain length before and abaft the midship section or for the whole of the vessel, said vessel is termed a "shade deck vessel." Partial awning deck vessels are those where the awning deck is not continuous from forward to aft and which have a raised forward or after deck.

2. Hatchways on second deck are to be fitted as if on an exposed deck, but depth of coaming need not exceed 12 inches.

3. The awning deck sheerstrake is to be ⅛ inch thicker than the side plating next below it in all cases.

4. All openings in the awning deck side platings must be efficiently compensated for.

5. When a curved gunwale is adopted the stringer plate must be laid flat on the beams for its full tabular breadth.

6. Longitudinal and diagonal tie plates must be fitted to the awning deck and the deck below when said decks are not plated. The second and upper deck must be plated or covered with wood.

7. A reduction of ¼ from the thickness of the second deck planking will be allowed for the awning deck, but no plank to be less than 2½ inches thick.

8. A required partial or complete deck is to be fitted to the second deck. With more than one plated deck the thinnest one is to be fitted to the awning deck.

35. Raised Deck Vessels.

1. In this type the upper deck is interrupted and raised at the after end, the forward part of the deck being fitted with a forecastle built in the ordinary manner, or raised in the same manner as the quarter deck.

2. The height of the raised deck above the upper deck is to be added to the molded depth to the upper deck in determining the arrangement of lower deck beams, hold stringers and reverse frames in way of the raised deck.

3. A maximum load must be fixed for vessels built with both a raised quarter and a raised foredeck.

4. *a.* The thickness of the side plating of the raised deck above the main sheerstrake is to be the same as required for the side shell plating. Said side plating shall extend 2 or 3 frame spaces beyond the break.

b. If the length of a raised deck exceeds ¼ the vessel's length the side plates at the break are to be ⅛ inch thicker; the adjoining plates before and abaft being ⅛ inch thicker than otherwise.

c. If a gangway or cargo port interferes with the above arrangement the sheerstrake is to be worked double for at least 20 feet in way of the brake.

d. In vessels with both a raised quarter and a raised fore deck the upper deck sheerstrake is to be worked continuously from the stem to stern, being ⅛ inch thicker at each break than otherwise.

5. Wood decks can be ½ inch less in thickness than otherwise when the length of the raised deck is less than ¼ of the vessel's length, but they must not be less than 2½ inches thick in any place.

6. In way of a break both the raised and the main decks are to be plated over from stringer to stringer, so as to provide proper means of attachment for the brackets between said decks.

7. *a.* When the length of a raised deck is over ¼ the vessel's length, the stringer plates of said deck are to continue for three frame spaces beyond the break, gradually tapering for said length to the width of the main rail.

b. The upper deck stringer is also to extend beyond the break bulkhead for three frame spaces, being clipped to the side plating for said length.

8. *a.* In vessels with both a raised quarter and a raised fore deck the upper deck stringer must continue under the raised deck for a distance equal to three times its width with a gradual taper from full width to that of the frame for said distance. It should be clipped to the shell plating.

b. In said vessels the raised deck stringer is to be worked continuously, being secured to the shell by a single angle bar.

9. No doors will be allowed in the end bulkheads of raised decks or of bridgehouses.

36. Poops: Forecastles: Bridgehouses: Deck Houses.

1. The side plating of the poop is to extend forward of the front of the poop 2 or 3 frame spaces; the plates at the break being increased by ⅛ inch in thickness. These requirements apply to both ends of a bridgehouse.

2. *a.* When the length of any of these structures exceeds ¼ of the vessel's length, the sheerstrake is to be doubled and the stringer plate increased by 20 percent in thickness for at least 20 feet in way of the front of a poop, the after end of the forecastle and of both ends of a bridgehouse.

b. When the combined length of a poop and bridgehouse, of the poop and raised quarter deck, or of either one of said structures exceeds 2-5 of the vessel's length, when said vessel's longitudinal number exceeds 125,000, the upper sheerstrake is to be doubled for ½ length amidships with plating equal to that of the strake next below; or its thickness increased by ½ of its tabular midship thickness for same length. If the bridge side plating and stringers are increased over at least 2-5 of the vessel's length said increase of sheerstrake can be omitted.

c. When the combined length of any two of these structures or the length of any one exceeds ½ the vessel's length in a vessel whose longitudinal number exceeds 125,000 said doubling of the sheerstrake, etc., is to extend for ¾ of the vessel's length amidships.

3. With a curved gunwale the stringer must lay flat on the beams for its full width and the gunwale strake brought up to meet it.

37. General.

1. All steel and iron vessels should be examined in dry dock at least once a year.

2. All metal parts of a vessel and all wooden decks which are worn to less than ¾ of their original required thickness must be removed and replaced by material of the proper requirements.

3. All anchors, chain cables, rigging, etc., must be replaced when their sectional area or weight has been reduced to ¾ of their original required value.

38. Spacing of Rivets.

	Diam.
1. Center of rivet from edge of a plate or angle bar (not less than)	1½
2. Center to center of rows; zigzag riveting	2
3. Center to center of rows; chain riveting	3
4. Single and double riveted butts; two inner rows of treble riveted butts with single straps; single riveted seams of shell plating; butts and seams of wateams of shell and bottom plating; treble riveted	
5. Single riveted seams of decks; double riveted sertight bulkheads, double bottoms, etc.	3½
lapped butts	4
6. Treble riveted double strapped butts; double riveted seams, except those of the shell and double bottom plating; quadruple riveted butts	4½
7. Forgings; connections of floors and frame brackets to the center girder and tank top margin plates: engine and thrust block foundations; framing immediately below same; beam knees (see 12 below); side plated rudders	5
8. Third row of a treble riveted single strapped butt; connection of shell plating to frames and stringers from the keel up to the load line for about 20 percent of the vessel's length aft from stem when the longitudinal numeral exceeds 250,000	5¼
9. Frames and reverse frames to each other and to floors; frames to shell plating; angle bars of beams, keelsons and hold stringers; bulkhead stiffeners, etc.	7
10. Bulkhead stiffeners arranged entirely inside of a deep water ballast tank	5 to 6
11. Stringer plates and deck plating to beams	8

12. At least four rivets are to be put in each side of a beam knee, one of which in case of a plate knee is to pass through the beam itself.

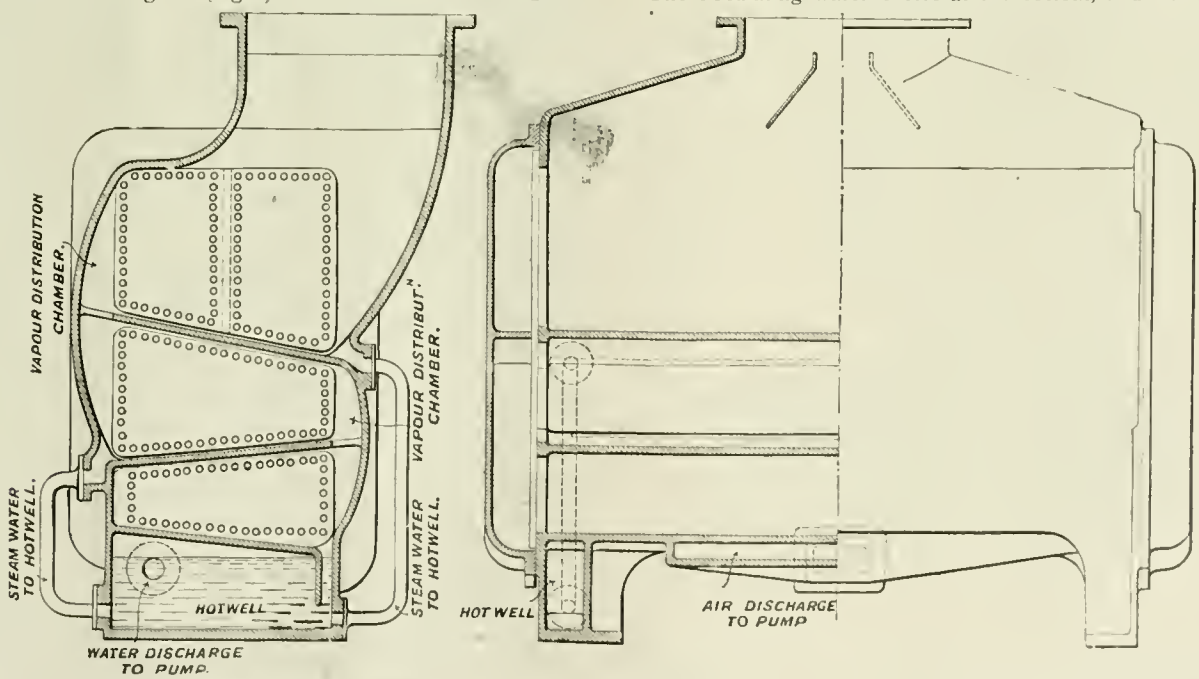
(To be continued.)

ENGINEERING SPECIALTIES.

The Contraflo Condenser.

A condenser of modern design which is rapidly coming into extensive use both for land and marine purposes is the Contraflo condenser. Fig. 1 (right) is a half elevation and half vertical longitudinal section. Fig. 2 (left) is a cross section, showing the water drainage arrangements. The steam enters the condenser at the top and passes in succession through the three compartments, being conveyed from one to the other of these by the tubeless passages or distributing chambers shown in Fig. 2. The air is discharged to the pump from the bottom of the condenser; but the water of condensation is dealt with separately, each compartment having its own independent pipe or passage for drawing off the water to a hotwell situated at the bottom of the condenser, or elsewhere, as preferred.

The circulating water enters at the bottom, and makes several passages through the tubes, leaving the condenser at the top. The general direction of the steam is thus opposite to that of the water, but the actual path of the steam through the several compartments is at right angles to the flow of the water; hence the name: Contra-flow.

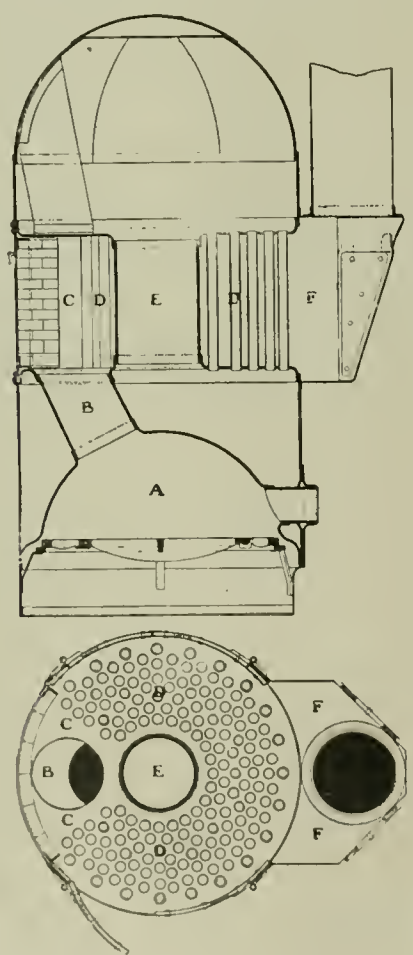


The admission of the steam at the top of the condenser and the withdrawal of the air from the bottom allows of the highest vacuum being obtained under given conditions, as has been proved by experience; and the placing of the water inlet and outlet respectively at the bottom and top enables the air just before it leaves the condenser to come into contact with the coldest tubes, and thus to reach the air pump with a minimum volume and containing a minimum amount of water vapor. At the same time the arrangement promotes economy of water, and it also allows of a high hotwell temperature being obtained, as the top compartment, which supplies most of the hotwell water, is subjected to the least cooling action.

The three compartments of the condenser are of continually diminishing section so that as the volume of the steam is reduced through condensation, its velocity remains approximately constant. The tubeless passages are also successively reduced in maximum cross-section to suit the diminishing volume of the steam. The steam is thus distributed equally over the whole cooling surface, and passes through the condenser with uniform velocity in smooth easy-flowing stream lines.

The Riley Patent Water-Tube Boiler.

This boiler, which is of the water-tube type, has been designed and patented to meet the demands for a vertical donkey boiler, which is simple in construction, reasonable in price, durable, easily cleaned and repaired, and economical in fuel. As will be



seen from the illustration, the shell of the boiler is cylindrical, and is made up of two plates, the lower one, into which is placed a circular tube plate and the firebox, and the upper one, to which is attached the crown of the boiler and the upper tube plate. The space between the tube plates, which is closed in by a fire brick back, asbestos-packed doors, and the smokebox, and is the full length of the tubes, forms a large and free combustion chamber.

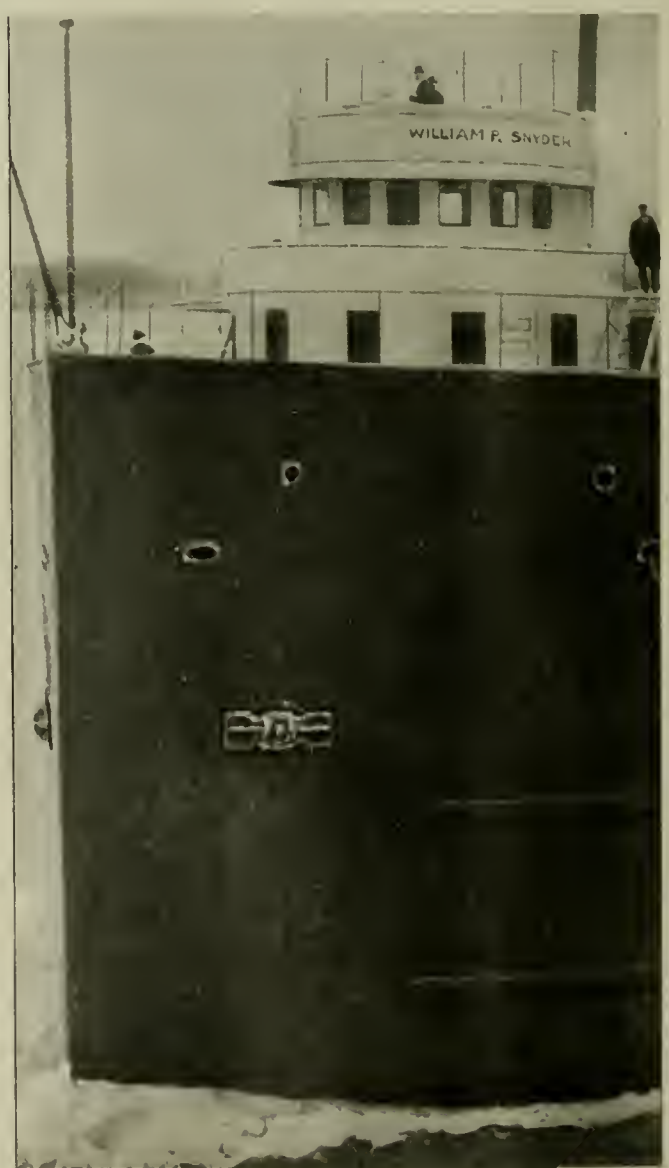
The firebox A, is of the hemispherical form: the products of combustion are led by an incline tube B, into the combustion chamber C, and after passing at right angles among the small tubes D, and being split up by the central tube E, are then discharged into the smokebox F at low temperature.

All parts of the boiler are fully accessible for cleaning, the occasional use of a steam blast through the casing doors being said to be all that is necessary to keep the tubes and tube plates free from soot and dust. Every part of the boiler exposed to the hot gases is covered with water, and can be easily repaired or renewed. All tubes are straight, vertical and of equal length, and can be withdrawn into the upper steam and water space.

The boiler has good circulation, a large water area for the liberation of steam, low funnel temperature and high efficiency of heating surface. Easy access to the lower end of the tubes and to the firebox top is obtained by means of the large central tube, which forms a passage through the combustion chamber. The boiler is marketed by Riley Bros., Limited, Stockton-on-Tees, England.

A Patent Hawse Pipe.

From time to time there has been serious damage caused by the projecting anchors of ships. The hawse pipes also have been



the source of considerable trouble, and at times have been dangerous for the reason that a ship, especially one heavily loaded

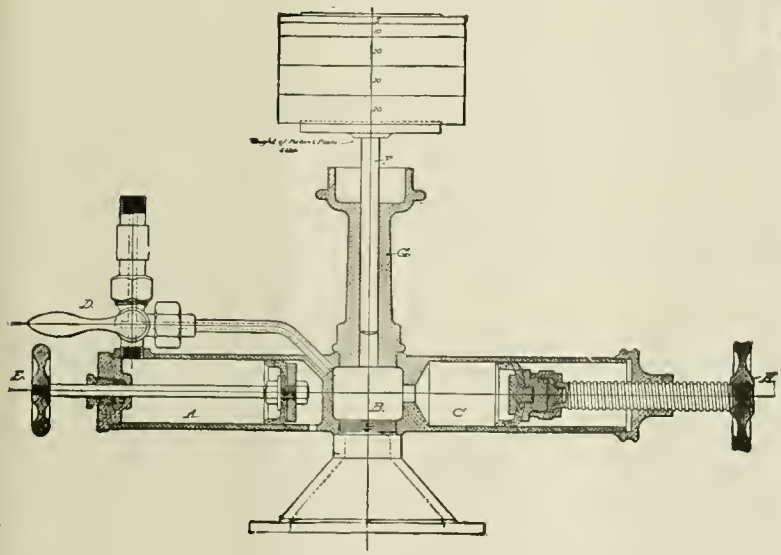
and running in a head sea, has had the water forced up through the pipes and into the forward part of the vessel. At times a sufficient quantity of water has been taken in through the hawse pipes to seriously endanger the ship.

The hawse pipe used on the steamer *Wm. P. Snyder,* built by the Great Lakes Engineering Works, of Detroit, Mich., the bow of which is illustrated herewith, is so constructed as to admit of the flukes of the anchor being drawn inside the hawse pipe, therefore leaving nothing projecting excepting the base of the anchor. This not only removes from the outside of the ship the dangerous projection of the anchors generally in use, but it also closes over the end of the hawse pipe, thus preventing a ship's taking water through the hawse pipes when running in a head sea.

The American Gauge Tester.

A dead weight gauge tester, with improvements which make principally for increased facility in handling the apparatus, has been brought out recently by the American Steam Gauge & Valve Manufacturing Company, Boston, Mass. The claim is made that it possesses all the advantages of the mercury column, inclosed in a much smaller space, and that it can be relied upon to be absolutely accurate at all times.

The sectional view shows the principal parts of the pump to be a chamber B, connected directly with the gauge to be tested, and the cylinder G, containing the piston F, upon which the



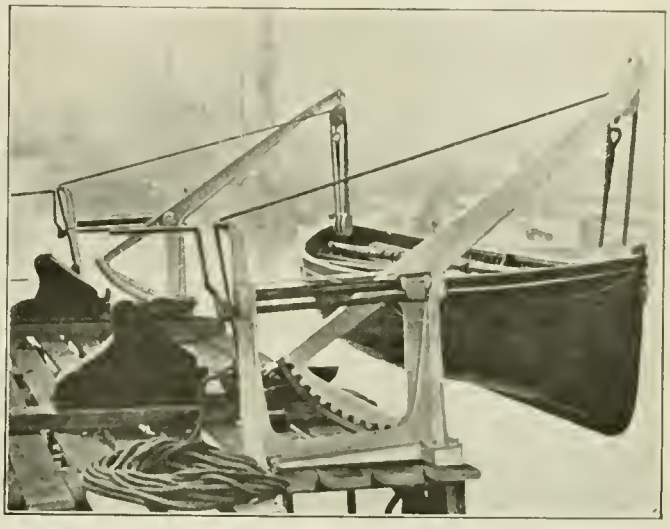
weights act, the cylinder C having a screw plunger for raising the piston F under weight and the auxiliary oil chamber A having a plunger for filling the connection between the gauge and the main chamber G through the three-way cock D. The weights and the area of the piston F are proportioned to produce directly on the gauge to be tested the pressures indicated on the weights. The oil is contained within the pump at all times, eliminating the necessity of pouring it in and out before and after testing.

Before disconnecting the gauge the handle of the cock D is turned down and the handle E is pushed in. All oil is thus drawn off or drained from the gauge tube into the chamber A, preventing spilling of oil when the gauge is disconnected.

Welin Quadrant Boat Davits.

The swinging davits now in general use on merchant ships are not a particularly satisfactory means for launching lifeboats at sea, the manipulation of the davits being effected by the pushing and pulling of the boat. To offset the disadvantages due to the older form, a device has been patented by Alex Welin, which is illustrated by a cut on this page. In this device the lower end of the davit is made into a toothed quadrant, of which the teeth fit into corresponding meshes in the base of the outfit. The center of the quadrant forms a fulcrum, about which the whole is rotated, while at the same time this center is traversed outboard for the purpose of launching the boat. The motion is such as to carry the boat out over the side, by both the traversing and the rocking effects, the operation being performed by means of a screw gear working through the fulcrum. One man at each end of a boat can handle the apparatus, even when it has a considerable load upon it.

This device has been adopted on a number of the most recent

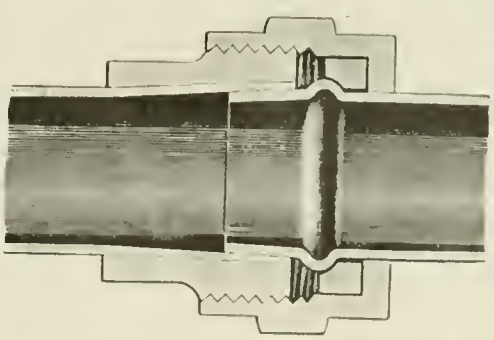


steamships, prominent among which might be mentioned the *Cedric, Victorian, Virginian* and *La Provence,* and was illustrated in connection with the latter ship on page 223 of our issue for June. The device is placed upon the market by Mr. Welin, at Hopetoun House, Lloyds avenue, London, E. C., and is handled in the United States by A. P. Lundin, 49 Wall street, New York City.

A Patent Compression Pipe Joint.

The "Compression" joint is designed for connecting copper, brass, and other tubes of light gage, to avoid the difficulty of screwing. One pipe end is forced into the expanded end of the opposing pipe, compressing it into a taper form on the spigot end, which beds itself firmly into the expanded end, making a perfect metal to metal joint, no white lead or other jointing material being required.

In an ordinary union, where two pipe ends have to be screwed, and then a joint made in the union itself, it makes practically



three joints. Where pipes are united together by means of the "Compression" joint, the connection is complete with only one joint, the pipe ends being forced into each other. This joint can be made in considerably less time than by other means, effecting a great saving in labor, and can be easily disjointed for cleaning. The fittings are placed upon the market by J. M. Leigh & Son, 67 Deansgate, Manchester, England.

PERSONALS.

The Right Honorable W. J. Pirrie, chairman of Harland & Wolff, Limited, of Belfast, has been made Lord Pirrie of Belfast. The new peer was born in 1847 at Quebec, and was educated at the Belfast Royal Academical Institution. He has been connected with the shipyard since 1862, having been made a partner in 1874.

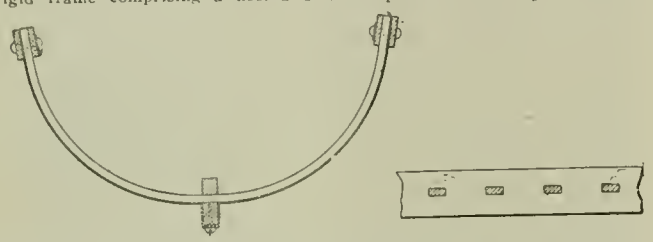
On the birthday of His Majesty, King Edward VII, June 29th, Mr. John Williams Benn, senior partner of our publishing company, 8 Finsbury Square, London, E. C., received a knighthood, and became Sir John Williams Benn.

SELECTED MARINE PATENTS.

The publication in this column of a patent specification does not necessarily imply editorial commendation.

810,784. METALLIC BOAT. WILLIAM H. MULLINS AND WILL C. HARE, SALEM, OHIO.

Claim.—6. In a motor-driven boat, the combination of a permanent rigid frame comprising a keel and a bow-piece and stern-pieces forming



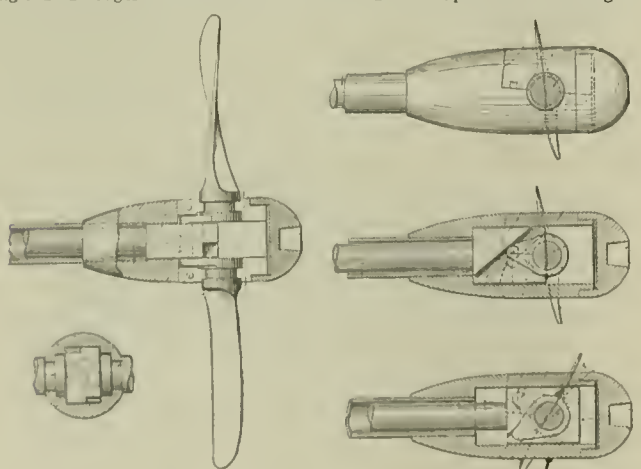
continuations thereof, gunwales and connecting-ribs, and a metal shell covering said frame and secureed thereto at the gunwales and keel and bow-piece and stern-piece only. Six claims.

821,925. POWER TRANSMISSION FOR EXPLOSIVE-MOTOR-DRIVEN BOATS. WILLIAM E. COLLIER, MUSKEGON, MICH. ASSIGNOR TO RACINE BOAT MFG. CO., MUSKEGON, MICH. A CORPORATION OF MICHIGAN.

Claim.—1. A propelling mecbanism for boats comprising an explosive-engine, its crank-shaft, a valve mechanism for controlling the supply of explosive admixture to the engine, an electric ignition mecbanism provided with a member which is adjustable to change the sparking period, a propeller-wheel provided with blades which are angularly adjustable to vary the pitch thereof, an endwise-movable propeller shaft connected with the propeller-blades and acting by its endwise movement to change the pitch of said blades, a movable cam-plate, operative connections between said cam-plate and said propeller-shaft, producing shifting movement of said cam-plate in the endwise movement of said propeller-shaft, and operative connections between said cam-plate, the valve mechanism and the adjustable member of the ignition mechanism, whereby the propeller-blades, the valve mechanism and the ignition mechanism are adjusted in unison. Five claims.

822,064. REVERSIBLE OR FEATHERING SCREW-PROPELLER. HARRY K. MILHAM, TWICKENHAM, ENGLAND.

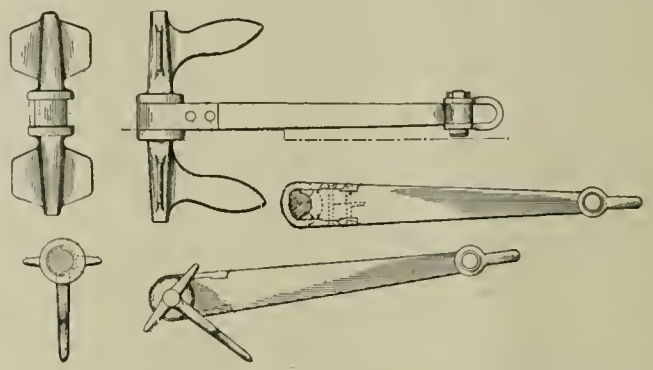
Claim.—1. In reversible or feathering screw-propellers; the combination with propeller-blades having spindle ends, and a hollow hub to receive the spindle ends of said blades said hub having an aperture through its wall extending forwardly from the rear end of same, the planes of the longitudinal edges of the wall of said hub at said aperture containing the



axes of said blades, said edges each having a semicircular recess at said axes adapted to receive half of a blade-spindle, and the forward edge of the wall of said aperture being inclined rearwardly; of a removable cover for said aperture, the longitudinal edges of said cover having semicircular recesses each adapted to embrace the remaining half of each blade-spindle, the forward edge of said cover being formed to contact and interlock with the forward edge of the wall of the hub at said aperture, means for detachably securing the rear end of the cover to the hub, mechanism contained within the hub for adjusting the blades about their axes, a tubular driving-shaft to carry the hub, and a rod passing through the driving-shaft for operating the blade-adjusting mechanism. Five claims.

822,097. STOCKLESS ANCHOR, GEORGE W. BOWDEN, RIDLEY PARK, PA.

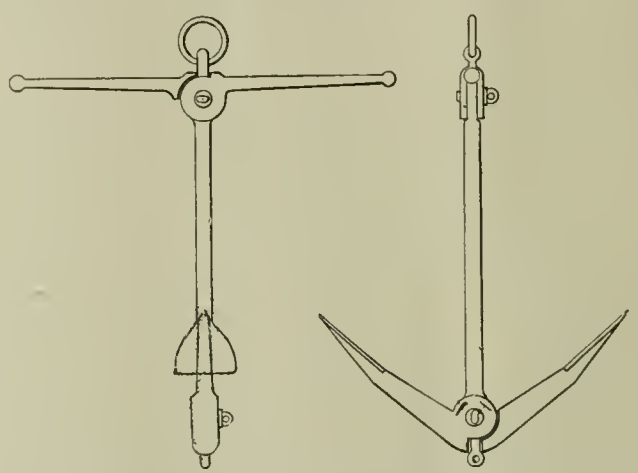
Claim.—1. In a stockless anchor, the combination with the shank, of



a concaved seat on the lower end of the shank and stops formed on the shank to one side of and above the said seat. Eleven claims.

822,420. ANCHOR. WILLIAM L. ADAMS, SOUTH PORTLAND, MAINE, ASSIGNOR TO GEORGE H. GRIFFEN, PORTLAND, AND JOHN E. FISHER, SOUTH PORTLAND, MAINE.

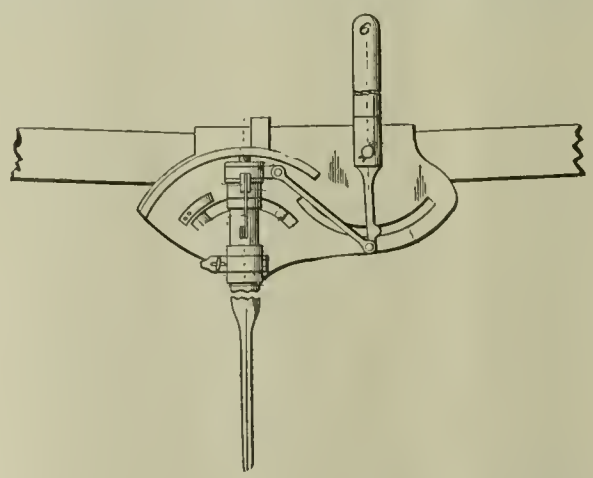
Claim.—2. In a folding anchor, the combination of a shank having near the lower end a circular plate with plain central apertures, arms pro-



vided with circular ears with central openings adapted to register with the opening in said plate, one of said openings being threaded, and a shoulder upon each arm beneath said ear adapted to contact with the side of the lower end of said shank, and a threaded pin for coupling the parts together. Four claims.

823,075. BOW-FACING OAR. JOHAN PETRICH AND LOUIS DULOVES, CHICAGO, ILL.

Claim.—1. In a bow-facing oar, the combination with a hinged, spring-balanced, supporting-plate, of an oar pivotally mounted on said plate, a segmental guide-bracket to receive and support the inner end of said oar,



an operating-lever pivotally mounted on said plate, a link pivotally connected to the outer end of said lever, antifriction-rollers mounted on said lever, a strap loosely connecting the inner end of the oar with the opposite end of said link, means to feather said oar at the end of the stroke, and means to restore the same to an operative position when brought back for a new stroke. Four claims.

g

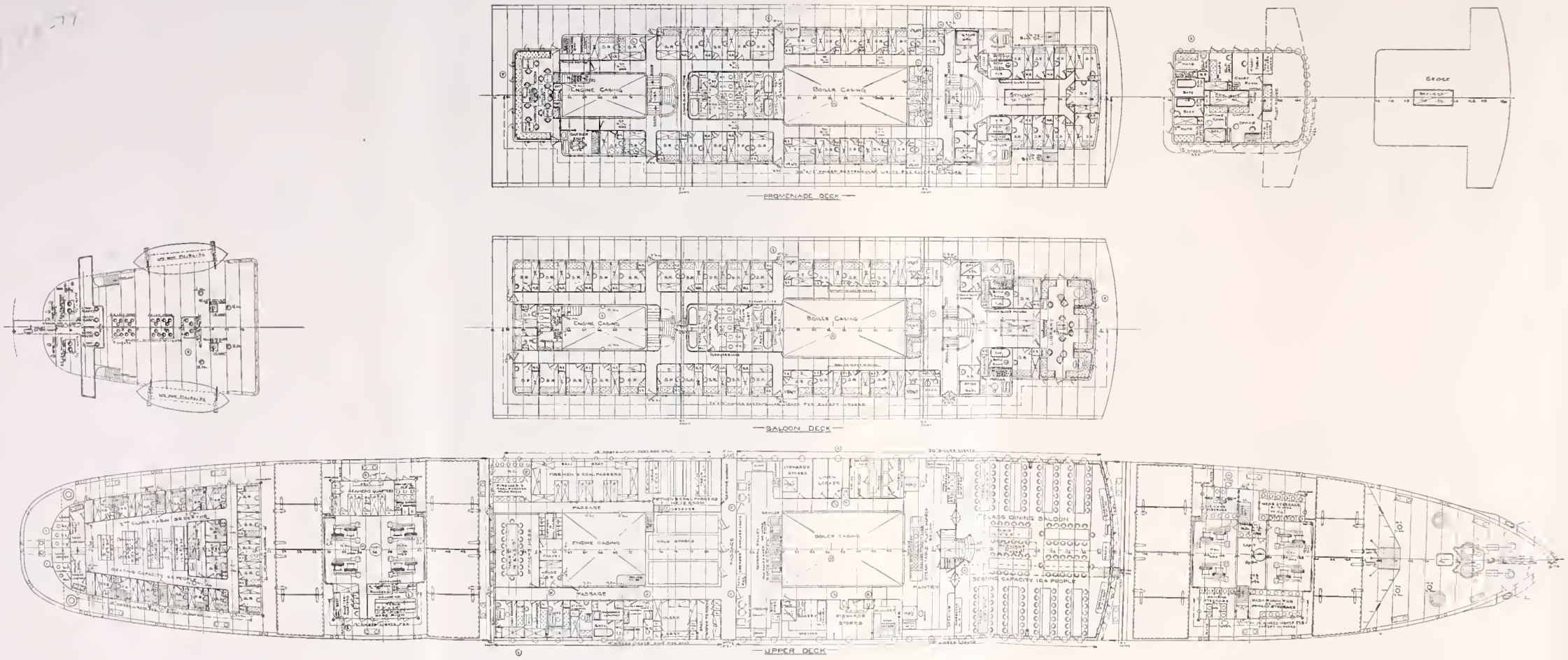
ıter. The hull
ven transverse
on the girder
ıns interfering

le against the
ng large cargo

ING.

ıe deck. The
ting the deck
ılf the length
t is continued
; girders, and
reated as the
.des the struc-
ting hurricane

comparatively
cking stresses



ACCOMMODATION PLANS OF UPPER, SALOON AND PROMENADE DECKS OF THE NEW TURBINE-PROPELLED SOUTHERN PACIFIC STEAMSHIP CREOLE, BUILT AND ENGINED BY THE FORE RIVER SHIPBUILDING COMPANY.

International Marine Engineering

OCTOBER, 1906.

TWIN SCREW TURBINE STEAMSHIP CREOLE.

The *Creole* is a steel steamship of the hurricane deck type, specially designed and constructed for the Atlantic Steamship Line of the Southern Pacific Company, by the Fore River Shipbuilding Company, of Quincy, Mass. She has a straight stem and semi-elliptical stern, and in elevation shows one large smoke stack and two short pole masts. She has a large superstructure on top of hurricane deck amidships, and superimposed deck houses.

in which is stowed fresh water and also ballast water. The hull is subdivided into watertight compartments by seven transverse bulkheads, and the cargo holds have been arranged on the girder system, which eliminates the usual hold stanchions interfering with the stowage of cargo.

The hull has been specially designed to provide against the weaknesses inherent in hurricane deck vessels having large cargo

DIAPHRAGM AND NOZZLES OF 120-INCH CURTIS TURBINE FOR STEAMSHIP CREOLE, SHOWING INSIDE OF THE CYLINDRICAL CASING.

THE HULL.

The following are the principal dimensions of this vessel:

Length over all	440 feet
Length between perpendiculars	416 feet
Breadth molded	53 feet
Depth molded, to upper deck	37 feet
Length of superstructure	182 feet

The vessel is intended as a first class passenger and freight steamship. The structural arrangement provides for three complete steel decks running all fore and aft, and an inner bottom carried about three-fourths of the length of the vessel amidships,

ports in wake of the over-all hatches on hurricane deck. The provision for extra strength consists in constructing the deck mentioned as the strength deck for about one-half the length amidships, and at the ends of the superstructure it is continued down to main deck by specially designed hogging girders, and from thence forward and aft the main deck is treated as the strength member. It will be obvious that this provides the structure with immense strength as compared with existing hurricane deck vessels.

On superstructure the midship houses are of comparatively light construction, specially braced to take the racking stresses

incident to their location on ship. In addition, expansion joints are fitted at forward and after ends of superstructure, to relieve these erections of undue stresses.

The subdivision of the vessel mentioned arranges for four cargo holds in addition to orlop, lower and main 'tween decks, the lower and main 'tween decks being pierced with large hinged cargo ports providing for the expeditious handling of cargo, in addition to which there are four especially large over-all hatches extending the full width of hurricane deck, giving roomy exits for handling freight.

The main deck provides accommodation at the extreme forward end for 252 passengers, in addition to which 168 passengers can be slung in hammocks, should occasion arise. Amidships on this deck have been fitted up quarters for waiters, pantrymen, cooks, etc., and alongside of the engine hatch are large insulated spaces for cold storage. After end of main deck has been arranged with second class staterooms.

The upper or hurricane deck has two steel quarter houses, one built forward and the other aft; the forward one containing shelter for four steam hoisters and also fitted up as wash room and toilet for steerage passengers, and the after one as seamen's quarters, mess room, wash places, etc., in addition to inclosing four cargo hoisters.

Amidships on upper deck a steel superstructure is constructed, having arranged at its forward end the first class dining saloon, with a seating capacity for 164 people. This saloon has a grand stairway at the after end leading to saloon deck, finished in mahogany. The saloon generally has mahogany wainscoting and furniture, and is finished in white, including panels and ceiling. The upholstery, tapestry and hangings have a dark green color effect, and the saloon is lighted around three sides by exceptionally large hinged air ports.

Adjoining dining saloon there has been arranged a commodious serving pantry with steam table, plate warmer, urns and all usual accessories and utensils commonly found in this department. The pantry is in close connection by spacious passages with the general galley.

At the after end of boiler casing, and at the sides of ship abreast this casing, the scullery, bakery, wine room, steward's stores and linen locker have been arranged.

Cold stores have been arranged at the forward end of the engine casing; and abreast of this casing, on port side, have been fitted up firemen's and coal passers' quarters and messes; and on the starboard side are engineers' staterooms, bath room, lavatories, etc., while at the after end of casing is the officers' mess.

Accommodations for 38 second class passengers are provided in a steel deckhouse at the extreme after end of vessel, comprising 19 staterooms, dining room (seating 44 people), pantry, and lavatories. A spacious promenade for the second class passengers is set apart on this deckhouse.

The saloon deck is formed by top of superstructure and extends for about 176 feet amidships. On this deck a steel house is-

CALKING DEVICE FOR SETTING BUCKET SEGMENTS IN THE RIMS OF THE ROTORS OF THE 120-INCH TURBINES.

constructed, inclosing accommodations for first class passengers, and comprising 34 staterooms, bath rooms, lavatories and a large library at the extreme forward end of staterooms. These staterooms are each two-berth rooms fitted with metallic berth fronts, side lights with ventilator above, colored glass, leaded sash, blinds, etc., and wash basins of the most approved type.

The library is 28 by 15 feet, and fitted up with tables, desks and lounge seats. The color effect is varying shades of blue, the whole having a green color effect in old Dutch finish. Adjacent to the smoking room on port and starboard sides respectively are placed the bar and barber shop.

The pilot house and officers' cabins are placed on boat deck. On this deck there are also arranged eight 27-foot metallic life boats with Mallory type davits for their expeditious operation.

Officers' and first and second class passengers' accommodations are heated throughout by electric heaters. Baths, showers and

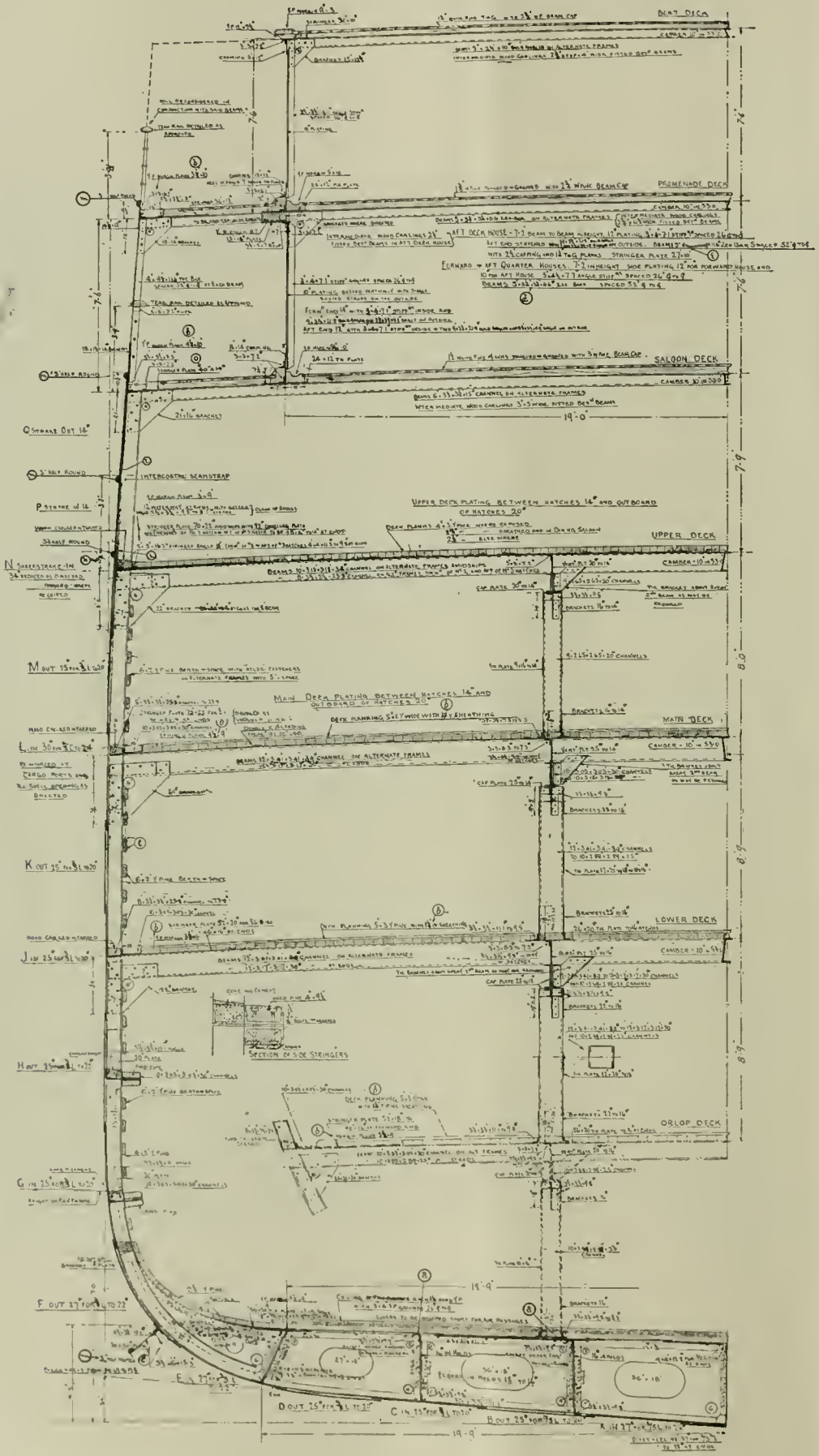
ANOTHER VIEW OF THE CALKING DEVICE FOR ATTACHING BLADE SEGMENTS TO ROTORS.

On top of saloon deck, the promenade deck house has been arranged inclosing 33 staterooms, some of which are en suite, with parlor and bath rooms. Two grand stairways provide access to saloon deck, and ample provision is made for bath rooms, lavatories, etc., amidships in this house.

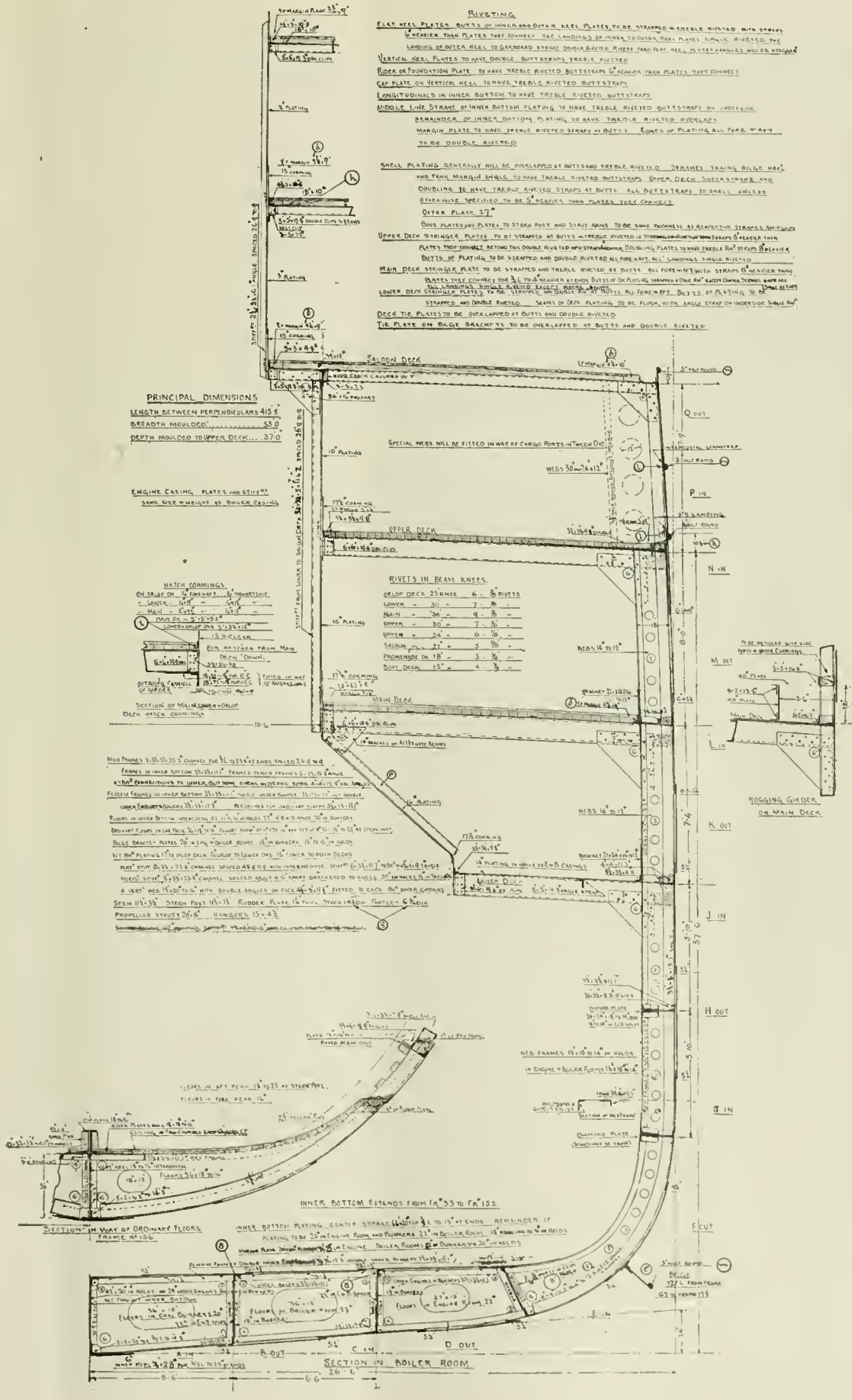
At the extreme after end of promenade deck house the smoking room is located in a space occupying 25 by 13 feet, and is fitted up in a luxurious manner with oak wainscoting and panels above.

wash hand-basins are fitted throughout with hot and cold fresh and salt water connections. Holds and accommodations are "naturally" ventilated throughout.

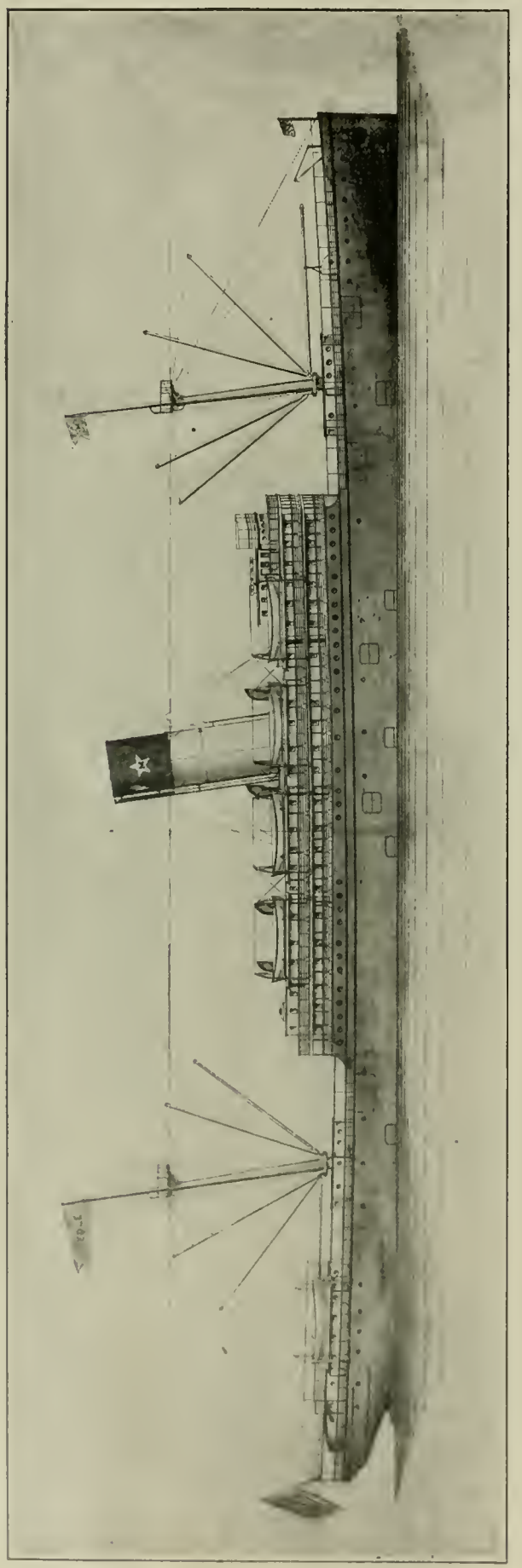
The cargo is handled through four large over all hatches and operated by sixteen 7½-ton capacity cargo derricks, and in addition one 20-ton cargo derrick supplied for handling exceptionally heavy lifts. These derricks are operated by eight double drum steam winches of the frictional gear type, manufactured by the



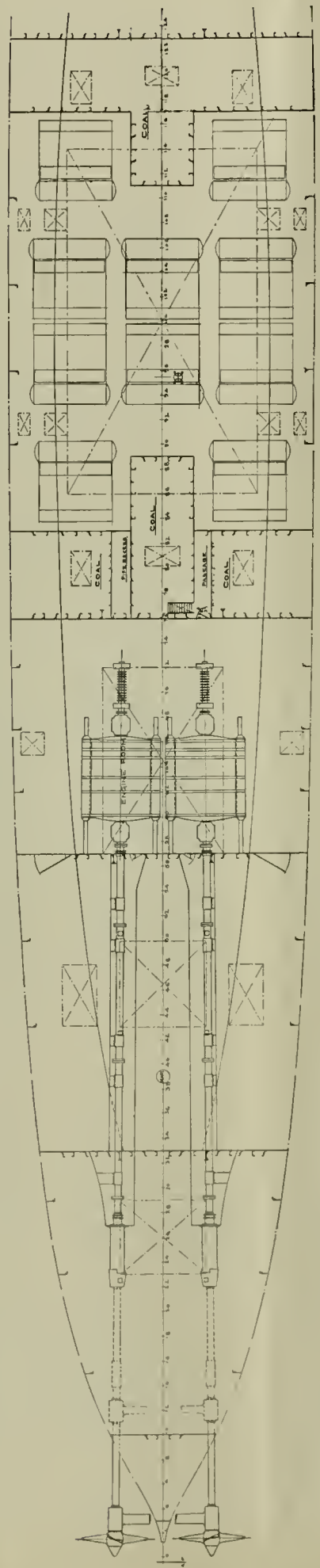
SCANTLING SECTION OF SHIP AT MID LENGTH OF HULL.


RIVETING
PRINCIPAL DIMENSIONS
LENGTH BETWEEN PERPENDICULARS 415'
BREADTH MOULDED 53'0
DEPTH MOULDED TO UPPER DECK ... 37'0
SALOON DECK
UPPER DECK
MAIN DECK
RIVETS IN BEAM KNEES.
HATCH COAMINGS
ENGINE CASING PLATES AND STIFFRS
SAME SIZE & WEIGHT AS BOILER CASING
SPECIAL WEBS WILL BE FITTED IN WAY OF CARGO PORTS IN TWEEN DKS
SECTION OF MAIN LOWER & ORLOP DECK HATCH COAMINGS
SECTION IN WAY OF ORDINARY FLOORS FRAME No 156
SECTION IN BOILER ROOM
INNER BOTTOM EXTENDS FROM FR 33 TO FR 132
HOGGING GIRDER ON MAIN DECK

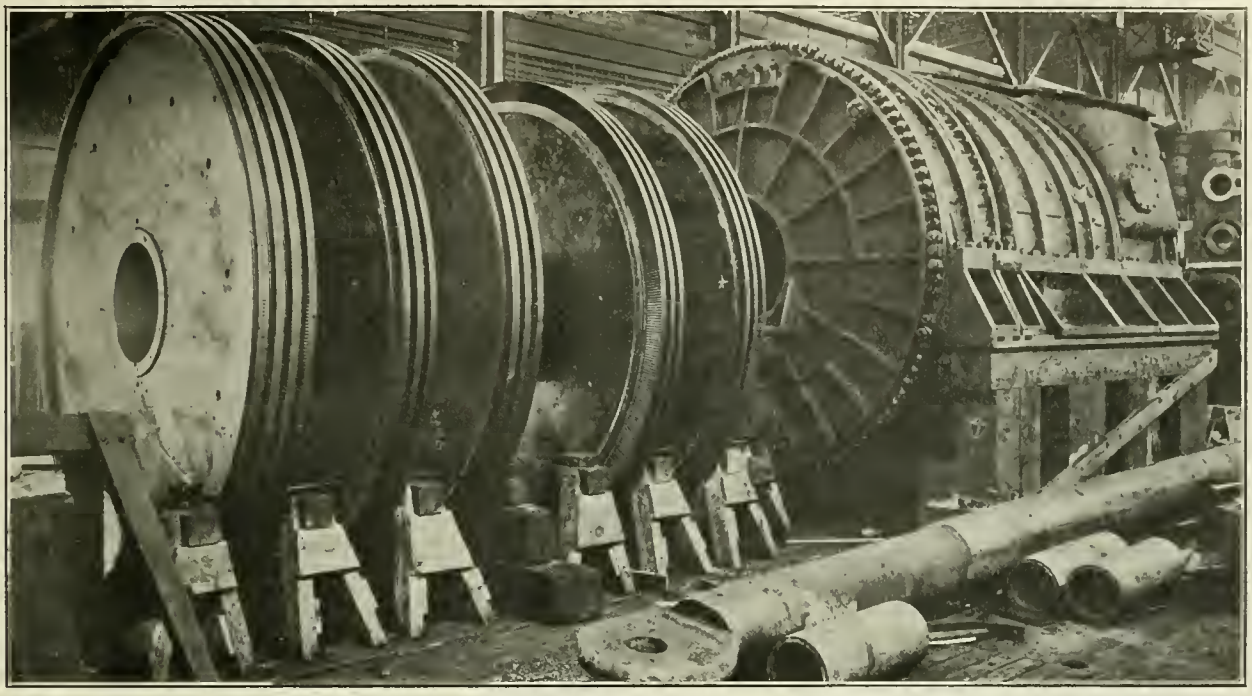
CROSS SECTION OF THE SCANTLINGS IN WAY OF BOILER ROOM.



THE NEW SOUTHERN PACIFIC STEAMER CREOLE, PROPELLED BY CURTIS TURBINES, AND BUILT BY THE FORE RIVER SHIPBUILDING COMPANY.



PLAN OF THE HOLD, SHOWING ARRANGEMENT OF THE TEN BABCOCK & WILCOX BOILERS AND TWO CURTIS PROPELLING TURBINES AND SHAFTING.

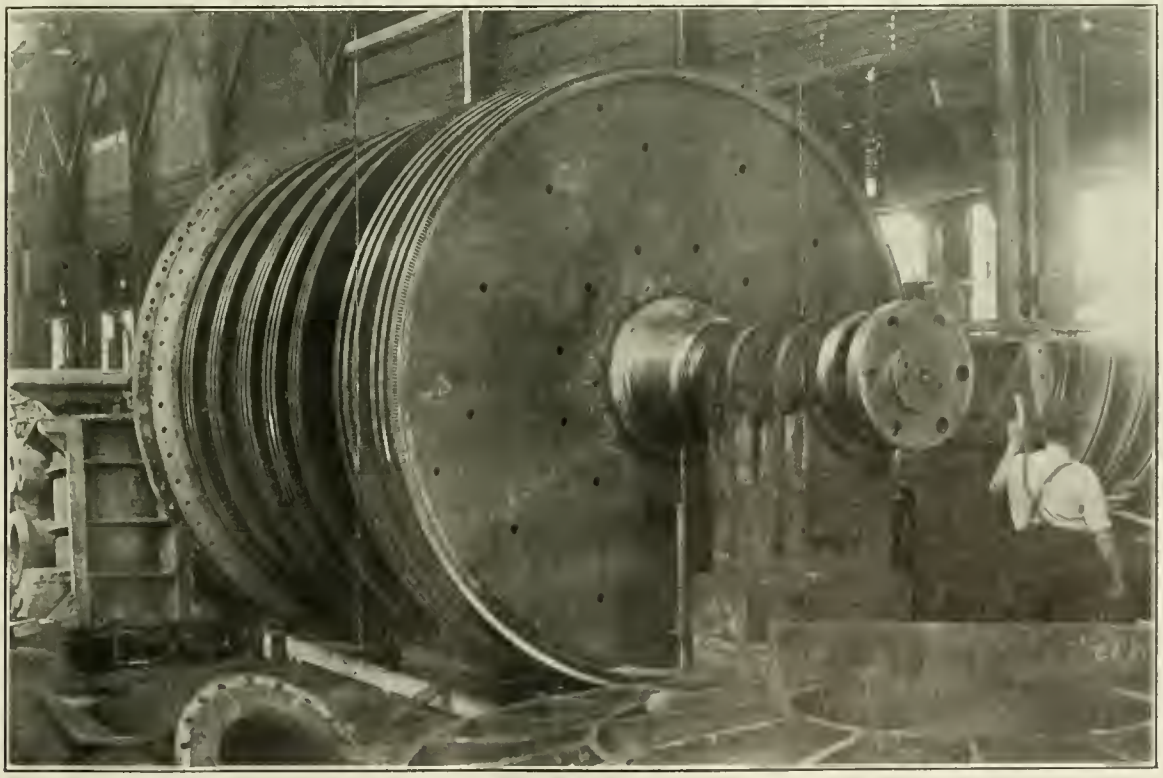


WHEELS READY FOR ASSEMBLING ON SHAFT. TURBINE CASING AT THE RIGHT.

Hyde Windlass Company. It should be noted that the pole masts are specially designed as king posts to take cargo derricks, and for this purpose the usual standing rigging, such as stays, shrouds and backstays, has been dispensed with.

The steam windlass gear consists of a specially heavy windlass of Hyde manufacture, with two vertical shafts driven by worm gearing direct from a worm located on engine crankshaft. The wildcats for operating cable are placed on the hurricane deck, and the steam engines for operating same are placed on main deck. In addition, these engines operate two warping capstans fitted on either side of forecastle head. A pair of warping capstans are likewise located aft on hurricane deck, operated by steam engine bolted under deck.

The steam steering installation is of the Hyde quadrant type, having engines bolted on the steam tiller, which is keyed to a rudder head of the Brown type. The steering gear is operated from the pilot house by wire rope transmissions to the engine valves, and is, in addition, so arranged that it can be operated by



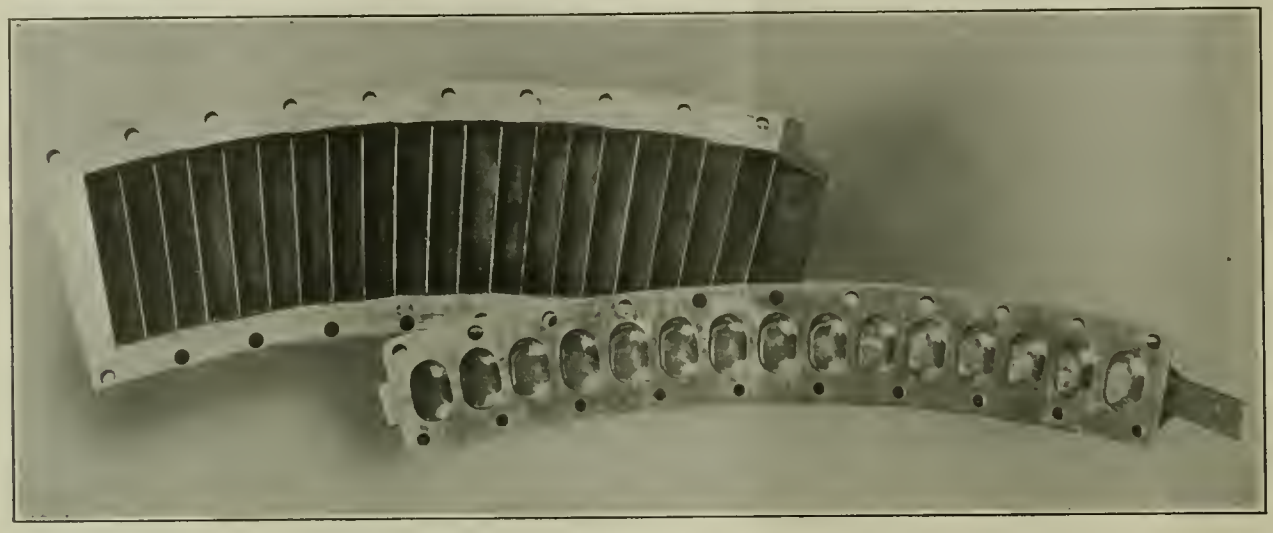
THE ASSEMBLED ROTOR OF ONE OF THE PROPELLING TURBINES, WITH DIAPHRAGMS IN PLACE.

hydraulic telemotor, to enable the vessel to be steered by the telemotor or with the transmission wire leads at will. In addition to above the usual hand and spare tiller steering arrangements are provided, to be used in the event of accident.

Coaling arrangements and boat handling gear are operated by two steam hoisters fitted on boat deck.

THE MAIN ENGINES.

The main propelling engines consist of two 10-foot reversing Curtis turbines, each having a rated capacity of 4,000 brake horsepower at 230 revolutions per minute, when operating at 250 pounds gage at throttle, with 100 degrees F. superheat and 27 inches vacuum. Each turbine has seven ahead wheels and two



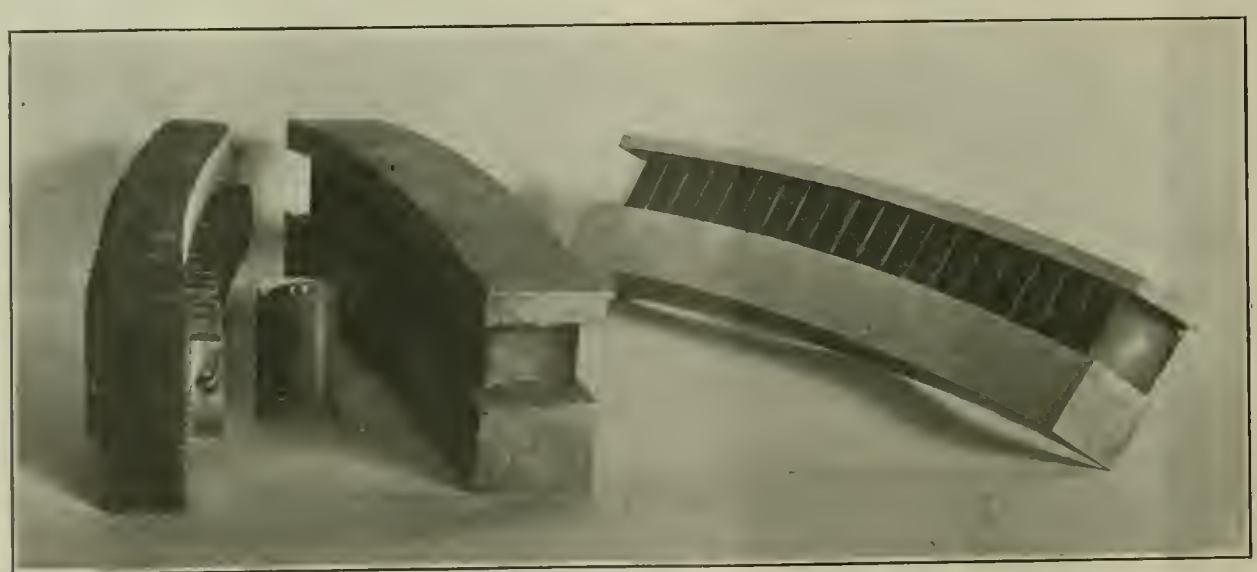
CURTIS TURBINE EXPANSION NOZZLES, FRONT AND BACK VIEWS.

In the engine room there is located a fire extinguishing and disinfecting machine of the Clayton type. This apparatus consists of a generator which can be charged with sulphur, and an air fan operated by steam with pipes leading to the holds, 'tween decks, bunkers, and all parts of the ship where freight or combustible material is carried. In addition to this provision for guarding against fire, there is the usual fire extinguishing installation required by law, which can be operated in conjunction with the Clayton apparatus at will.

Altogether the *Creole* in design, construction, equipment and appointments is probably one of the best and most complete vessels of her class afloat.* The equipment and appointments are of the highest order and the materials and workmanship throughout are of the best.

*She was launched September 23, 1906.

reverse wheels; each wheel has three rows of revolving buckets, except the first stage ahead, which has four rows. All wheels are inclosed in a cylindrical casing provided with diaphragms between the wheels, so that each wheel operates in a separate chamber. The first stage ahead wheel is in the forward end of the casing, and the first stage reverse wheel is in the after end. The seventh stage ahead wheel and the second stage reverse



B A C D

A, BRONZE BUCKET; B, BUCKETS IN CORE READY FOR CASTING ON BANDS; C, BUCKET SEGMENT, ROUGH CASTING; D, FINISHED SEGMENT.

wheel thus come next to each other, and as no diaphragm is between them they operate in the same chamber, which is connected direct to the condenser.

Stationary guide blades are carried on the inside of the casing and project between the rows of revolving buckets. Steam enters through nozzles in the forward head of the casing, and after passing through the buckets and guides of the first stage ahead wheel enters a second set of nozzles in the diaphragm

between the first and second stages; it then passes through the buckets and guides of the second stage wheel to similar nozzles in the diaghragm between the second and third stages, and so on through all the wheels and into the condenser.

The buckets all act on the impulse principle, the steam expanding and receiving its velocity as it passes through the various sets of nozzles in the diaphragms, therefore the pressure is equal on both sides of each wheel, and there is no end thrust due to the steam.

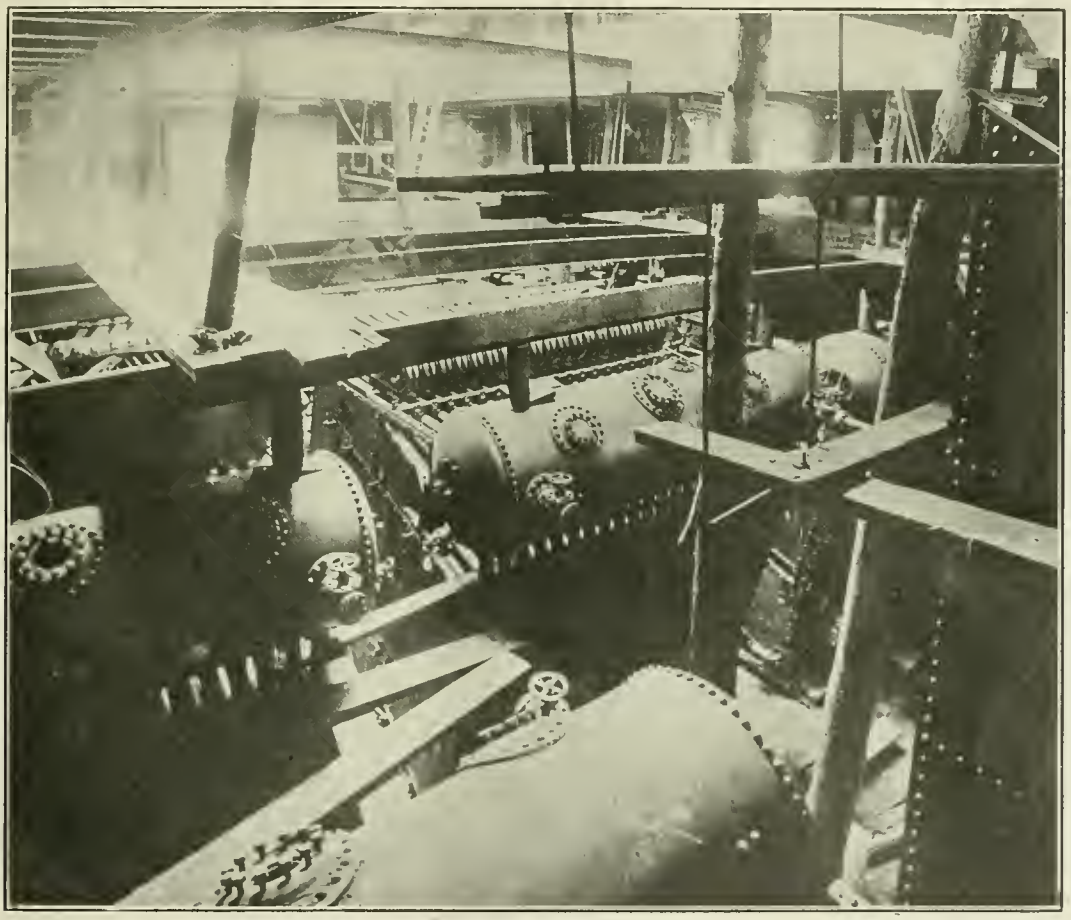
The nozzles on the first stage cover only a part of the circumference, the arc covered being gradually increased in the following stages; also the height of buckets is increased, so that the steam passage is increased in proper ratio, to accommodate the increased volume of the steam as it expands in passing from stage to stage.

stage into the annular space between the packings, so that only steam and no air will leak past the inside packing into the condenser, thus preventing the vacuum from being impaired. The leakage past the outside packing is the same as in the forward end, namely, the small amount due to a pressure of only 3 pounds per square inch.

There are two main shaft bearings, one at each end of the casing. They are of the self aligning type, with water circulation in the brasses, and arranged for forced flow of oil. The oil, after passing through the bearings, is filtered and cooled and returned to the supply tank.

The main shaft is extended through the forward bearing to form the thrust bearing, which is of the ordinary horeshoe type.

The casing, main bearings, and thrust bearing are all carried by



BABCOCK & WILCOX BOILERS INSTALLED ON SHIP, SHOWING SUPERHEATERS. BOILER CASING NOT YET FITTED.

Reversing is accomplished by shutting off steam from the ahead nozzles and opening the nozzles of the reverse wheels. This is done by interlocking levers on the operating platform, and the turbine can be instantly thrown from full speed ahead to full speed astern with no danger of injury and with much greater quickness and ease of control than is possible with the reverse motors of reciprocating engines. The reverse wheels will give 50 percent of full power. When going ahead, the reverse wheels run in full vacuum, and the power absorbed by them is negligible.

When the main shaft passes through the ends of the casing a special form of carbon packing is used to prevent steam leakage. Two sets of packing are used, with an annular space between, which is piped to the third stage shell, and has a pressure of only about three pounds above the atmosphere. On the ahead end the leakage of steam past the inside packing flows into the third stage shell, and the outside packing has to resist only the low pressure of 3 pounds, which will produce but the slightest leakage into the engine room. On the reverse end steam flows from the third

a structural foundation built up from the hull. The casing is built up of separate cast iron flanged sections, one for each stage, and all are divided in halves on the horizontal, so that the top can be removed for inspection. A continuous post is cast on each side of the casing and rests on a cast iron sole plate supported by the foundation. The forward end is rigidly fastened to the foundation, and expansion is provided for by allowing the after end to slide longitudinally on the foundation.

The axial clearance between the moving buckets and stationary guides in each stage is shown at all times by a small clearance indicator attached to the casing.

A fly ball governor driven by direct gearing to the reverse shaft operates a butterfly valve in the main steam. The governor is adjusted so that an increase of 10 percent above normal speed closes the valve.

A 5 by 5-inch double turning engine is provided, which operates through a worm wheel on the main shaft, and by means of a system of clutches can turn either turbine at will.

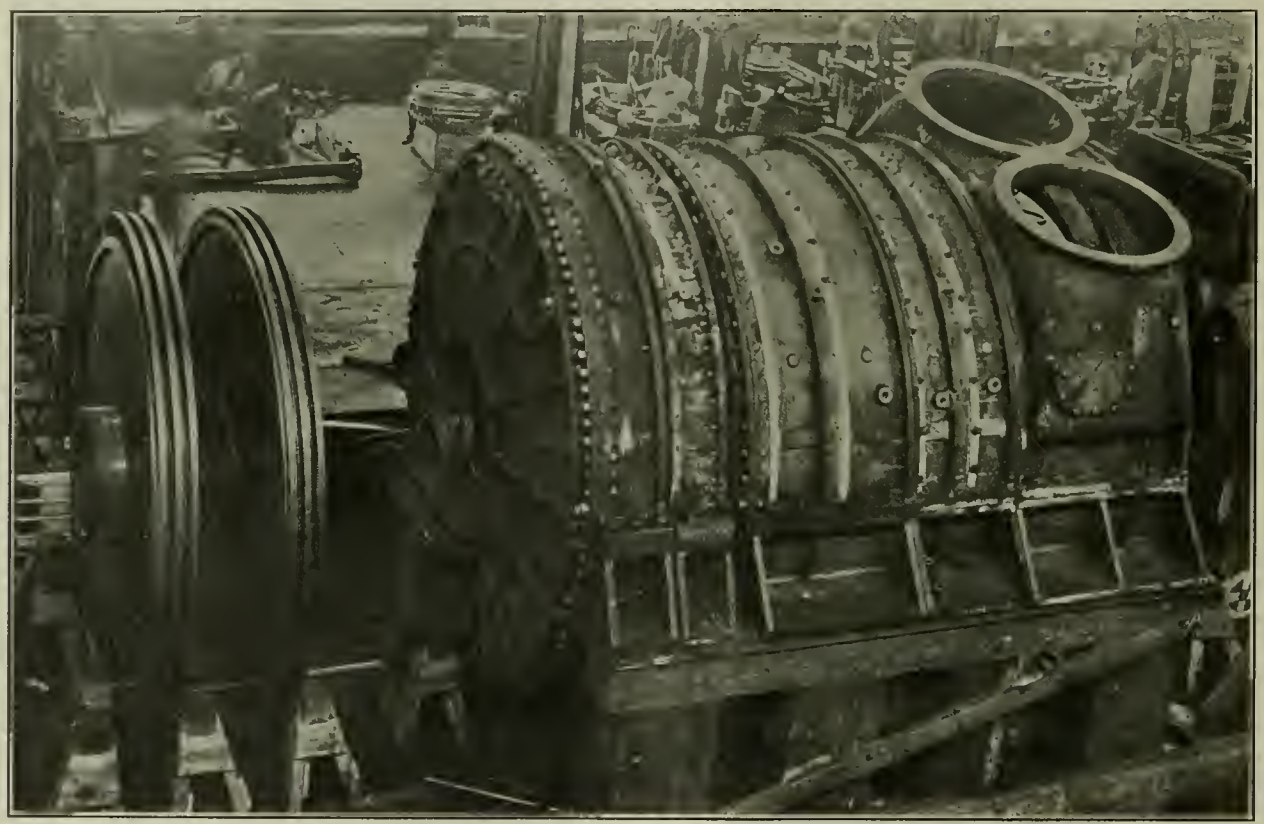
The method of blading is shown by the accompanying sketch.* The blades are made of extruded bronze; the process consisting of forcing the metal through steel dies. By this means the shape can be made very accurate and kept absolutely uniform; also a very smooth surface is produced, and the skin of the metal is made very tough. The sketch shows the shape of the section of the first row of revolving buckets and guide blades or intermediates on the first stage wheel.

The blades are held in place by casting them into a segmental base of section as shown. The ends of the blades enter about half an inch into the base casting, and the two metals fuse together and form practically one solid piece. The union is so perfect that when pulled in the testing machine the blade itself breaks instead of pulling out of the casting. The segment castings holding the revolving buckets are calked into the rims of the wheels, while those holding the intermediate guides are held by

AUXILIARY MACHINERY.

Main Condensers.—Each main turbine exhausts direct into a cylindrical shell surface condenser having 10,000 square feet of cooling surface, made up of ¾-inch outside diameter, No. 17 B.W.G. brass tubes, tinned inside and outside. The shell is made of 5/16-inch steel plate, heads and doors of iron, tube heads and supporting plates of brass; screwed stuffing boxes and cord packing is used. Each condenser, as fitted with jet injection, weighs 55,000 pounds, and is guaranteed to condense 66,125 pounds of steam per hour at 27 inches vacuum, with sea water at 85 degrees F.

Main Air Pumps.—Each condenser is provided with one vertical, double acting, air pump 14 by 14 by 26 by 18 inches, simplex, which is guaranteed to produce 27 inches vacuum in the condenser under the specified conditions. The water ends are of semi-steel, with composition liners, pistons, rods, stuffing boxes,



THE OUTSIDE OF THE TURBINE CASING, AND SIX DISKS OF BLADES ON THE ROTORS.

screws to the casing, as shown. Bronze strips of section as shown are riveted across the ends of all blades, thus supporting the outer ends and forming a closed passage for the steam.

The radial clearance can be as large as desired, without affecting the economy or operation of the machine, and is approximately half an inch. The axial clearance it is desirable to keep comparatively low. In the first row it is one-tenth of an inch, as shown, but in the later rows, where the pressure is less, it is increased to one-quarter inch.

The above solid construction and liberal clearances produce a machine that has small chance of accidental breakage. Of 400,000 horsepower of Curtis turbines in actual operation, not a case of blade stripping has ever occurred.

Not only is the design of this turbine patented, but the method of construction is similarly protected.

Propellers.—The propellers are 11 feet 6 inches in diameter, and have cast steel hubs and adjustable manganese bronze blades.

*See blade segments, page 386.

valve seats and fittings; steam cylinders are of cast iron. Weight 22,000 pounds each.

Main Circulating Pumps.—Each condenser is provided with one 20-inch horizontal, volute, centrifugal circulating pump, with inclosed composition impeller, composition shaft and self-ring-oiling bearings. The pump is directly connected to a 12 by 12-inch Reeves vertical simple engine operating at 290 revolutions per minute, when the pump is discharging 12,000 gallons of water per minute against a total head of 20 feet; under this condition an efficiency of 70 percent is guaranteed for the pump, and a steam consumption of the engine of 18½ pounds per indicated horsepower per hour condensing, and 22½ pounds non-condensing.

Auxiliary Condenser.—One auxiliary condenser with 12 by 14 by 16 by 16-inch horizontal single combined air and circulating pump is used. The condenser is mounted on top of pumps, and has a cylindrical wrought iron shell with 1,200 square feet of cooling surface. Total weight, 15,200 pounds.

Heaters.—A 60-inch "multi-coil" feed water heater is used, also two 6-inch Ebsen grease extractors, as made by the James Reilly Repair and Supply Company.

Pumps.—The following vertical, tandem compound, duplex pumps are used:

Main feed, 2, size 17 by 9 by 12 (not compound),
Donkey and fire, 2, size 8 and 14 by 6½ by 12,
Salt water sanitary, 1, size 5¼ and 7½ by 7 by 12,
Fresh water sanitary, 1, size 4 and 6 by 5 by 6.
Auxiliary sanitary, 1, size 5¼ by 5 by 6 (not compound),
Ballast pump, 1, size 8 and 12 by 12 by 12, horizontal.

STEAM GENERATING PLANT.

Main Boilers.—Ten Babcock & Wilcox marine type water tube boilers, each provided with a superheater, supply steam for all normal operation. They are designed for 250 pounds pressure and 100 degrees F. superheat, and have main tubes 4 inches in diameter, straight, and expanded into the regular Babcock & Wilcox sinuous headers. Superheater tubes are 2 inches in diameter, V-shaped and terminate in two straight parallel headers. The superheater is mounted on top of the boiler casing, and the baffles are so arranged that the hot gases pass through the superheater after their first passage across the tubes. After leaving the superheaters they pass twice across the main tubes. The boilers are arranged in one compartment, with two athwartship firing spaces; they operate under natural draft at all times.

Total grate surface, 770 square feet; heating surface, 28,500 square feet; ratio, 37.

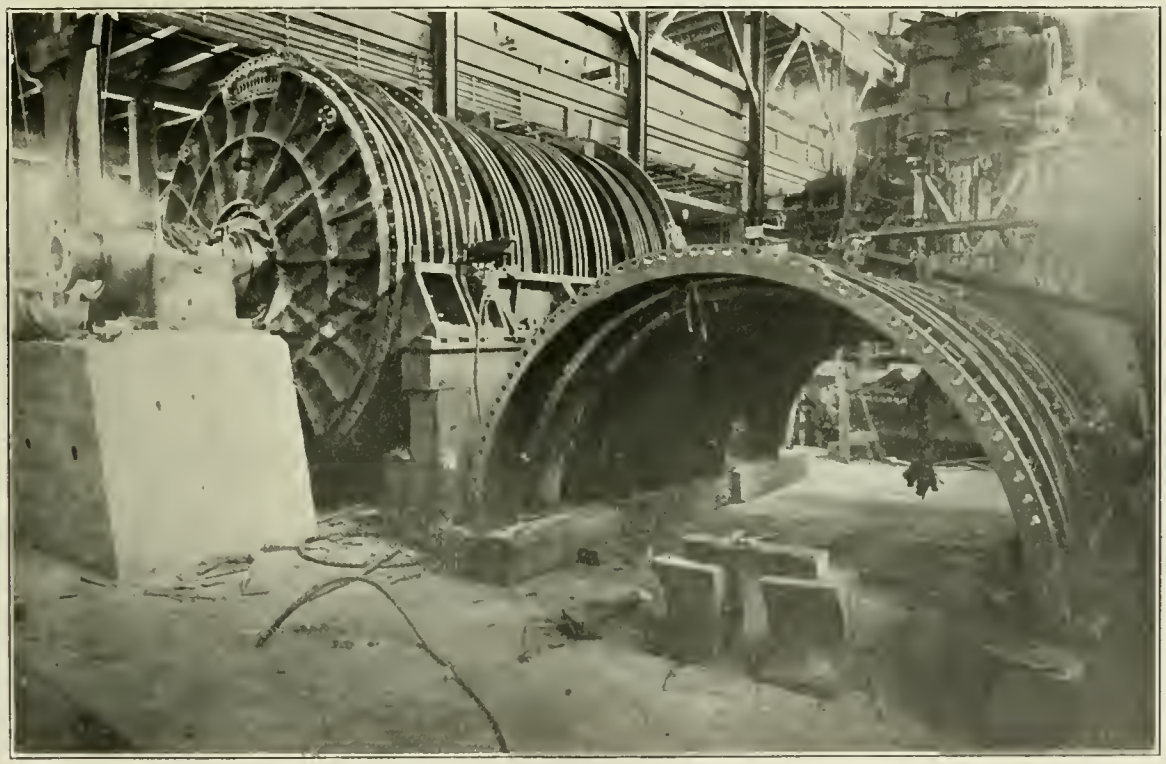
There are two elliptical funnels 15 feet 6 inches by 12 feet 6 inches, which rise 110 feet from the grates. To assist the fireroom ventilation there are four Sturtevant 55-inch steel plate fans driven by 3½ by 2½-inch double inclosed engines, each giving 4,000 cubic feet of air per minute at 660 revolutions per minute.

Two See 6-inch compound 60 degree ash ejectors are fitted in the firing spaces.

Steam Piping.—All steam piping is of seamless hot-drawn steel tubing with steel flanges. A 9½-inch diameter main steam pipe runs forward from each turbine, and has 4½-inch diameter branches to five boilers on one side of the vessel; a cross branch is run in the engine room, so that any combination can be used. The branches from the main steam pipe to each boiler run to one flange of the cross stop valve, the other flange being connected to one end of the superheater through a globe valve. The other end of the superheater is connected to the angle stop valve of the boiler. This arrangement allows steam to be taken direct from the boiler or through the superheater.

A 6-inch auxiliary steam pipe has branches to four of the boilers, in order to allow any of these boilers to supply steam for use on the auxiliary machinery. The auxiliary steam runs at 150 pounds pressure.

Donkey Boiler.—A horizontal internally fired donkey boiler is located in the upper 'tween decks. The shell is of ½-inch plate, 75 inches diameter and 12 feet 9 inches long, with 40-inch Morison corrugated furnace, and 166 tubes 2¼ inches in diameter, leading from the combustion chamber to the forward end. The heating surface is 573 square feet, and grate surface 14.16 square feet.



COMPLETED ROTOR ON SHAFT, WITH CASING ENDS IN PLACE. UPPER HALF OF CASING AT RIGHT.

ELECTRIC INSTALLATION.

The generating plant consists of two 75-kilowatt General Electric direct connected Curtis turbine generating sets and one 10-kilowatt engine driven set. They will operate at 110 volts direct current. The plant is located in the propelling engine room.

The distribution is on the two wire system, feeders from the generator board supplying numerous panel boards in cabinets located in various parts of the vessel; each panel board supplies the lights in its immediate vicinity on comparatively short distribution circuits. Steamtight fixtures with wiring in galvanized iron conduit used in all machinery spaces, freight spaces and hold. Living spaces are wired in molding, and have suitable fixtures to harmonize with the surrounding decorations. A total of about 860 incandescents will be used.

Electric heaters are installed in all the first and second cabin staterooms and officers' rooms amidships. These heaters are on circuits fed from the main switchboard independently of the lighting system. They are of the General Electric make.

Marine type, needle drop annunciators are installed, with wiring

in molding and pushbuttons in staterooms, and an automatic fire alarm system in conduit is fitted in the holds.

There is fitted an elaborate system of mechanical engine telegraphs, steering telegraphs and anchor, sounding and docking telegraphs, in the pilot house, and on the navigating bridge forward, and the warping bridge aft, together with voice pipes and voice pipe calling apparatus. The pilot house is equipped with a running light indicator, and electric shaft revolution indicators.

Electric bracket fans, direct connected exhaust fans, an electric dish washing machine, an automatic electric whistle operator and a 24-inch searchlight comprise the balance of the vessel's electric equipment.

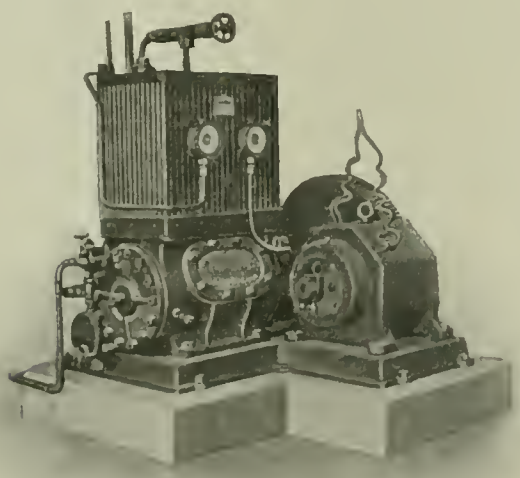
COLD STORAGE ON BOARD SHIP.

PART IV.

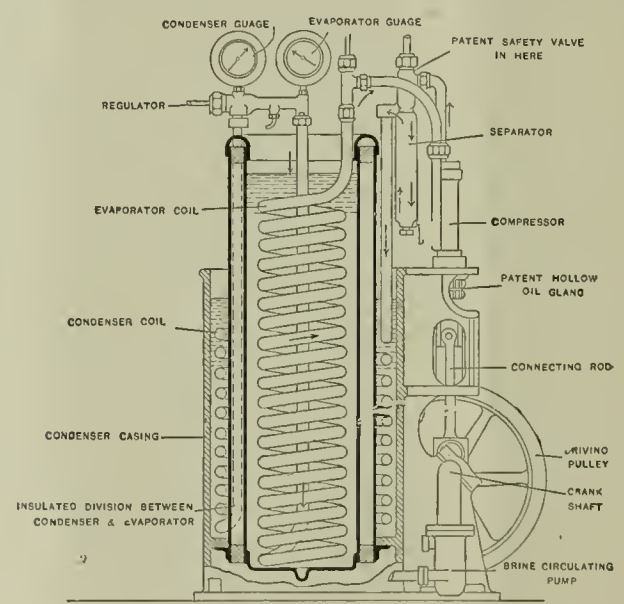
BY SYDNEY F. WALKER, M. I. E. E.

LEADING THE COOLED AIR INTO THE COLD CHAMBER.

There is one method of accomplishing this in all cases—by wooden ducts connecting the cooling chamber with the air chamber. These may be very large, where the air is cooled merely by the aid of a refrigerant—large enough for a man to walk in—and will contain ports opening into the cold chamber, fixed in positions where their opening will direct the current of air on to and over the surface of the produce to be cooled. The manipulation of the ports for regulating the air furnishes one reason for making the ducts large. Another and perhaps more important reason is the lessening of friction, and of power expended. Air, like brine and other fluids, rubs on the surface of the pipe or duct through which it is passing, and in rubbing sets up friction in proportion to the total rubbing surface, and to the square of the velocity at which it is traveling. Increasing the size of the ducts adds to the rubbing surface for a given length, but it also decreases the velocity of the air, and the gain by the latter is very much greater than the loss from the increased rubbing surface. Further, where produce is carried it is very important that dust and other objectionable matter shall not pass into the chamber, and this can be assured only by so arranging the ducts that they can be kept clean.



ENOCK 1¼-TON INCLOSED TYPE MOTOR-DRIVEN MACHINE.



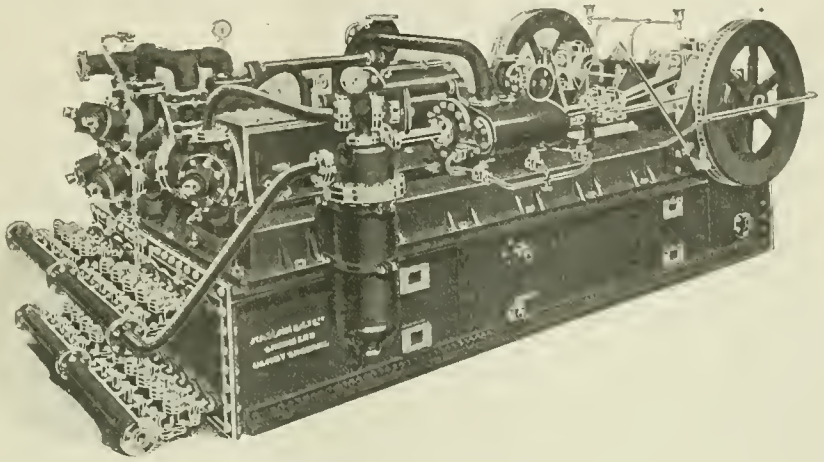
SECTION OF HALL CARBONIC-ACID COMBINED MACHINE.

The velocity at which the air passes over the surface of the produce has an important bearing upon preservation. Where the temperature does not matter, so long as it is below a certain figure, an air current at a high velocity will make no difference, but where the produce has to be maintained at a certain temperature, it has a great effect. When cooling by air, a certain quantity of air per hour must be passed through the cold chamber at a certain temperature. If the ducts are small, the air must pass through them at a higher velocity than when they are large, and it will issue into the cold chamber at a comparatively high velocity, with the result that the produce in the immediate neighborhood of the inlet ports will be exposed to great—possibly injurious—cooling effects, while that at a distance will receive only a much smaller relative effect. It is the same thing as with the drafts from which we catch cold. A draft is merely a current of air passing over our bodies or portions of them at a higher velocity than is good for us. Every cubic inch of air that passes over us extracts a certain number of heat units from our bodies, and principally from the part over which it passes. If these heat units are taken out rapidly the temperature of the body is lowered, particularly at the spot exposed to the draft, and congestion results. Similar results occur with produce.

The air ducts for ship work are practically passages surrounding the cold chambers, somewhat on the lines of the wing passages which used to surround the old wooden ships below the water line, along which a man could walk right around the ship, to stop shot holes, leaks, etc. They should form complete circuits for the passage of the air from the cooling grid and back to it again, with doors arranged to connect them to the cooling chamber and the atmosphere. With compressed air cooling, even where it is on a comparatively large scale, there is not much room for ducts, both because warming of the cooled air would take place largely in the ducts, and because of the friction mentioned above. The air cooled by compression and expansion is led to the cold chamber by the shortest possible route, the air duct being thoroughly well insulated. The use of the large air ducts described has the disadvantage that they absorb a good deal of room that could otherwise be filled with cargo, but the arrangement is much the best for certain classes of produce, such as fruit.

Where the cooled air system is employed with two or more substances, having odors of their own, the ducts leading to the different chambers must not be allowed to connect in any way. The inlets of one must not be near the outlets of the other, and

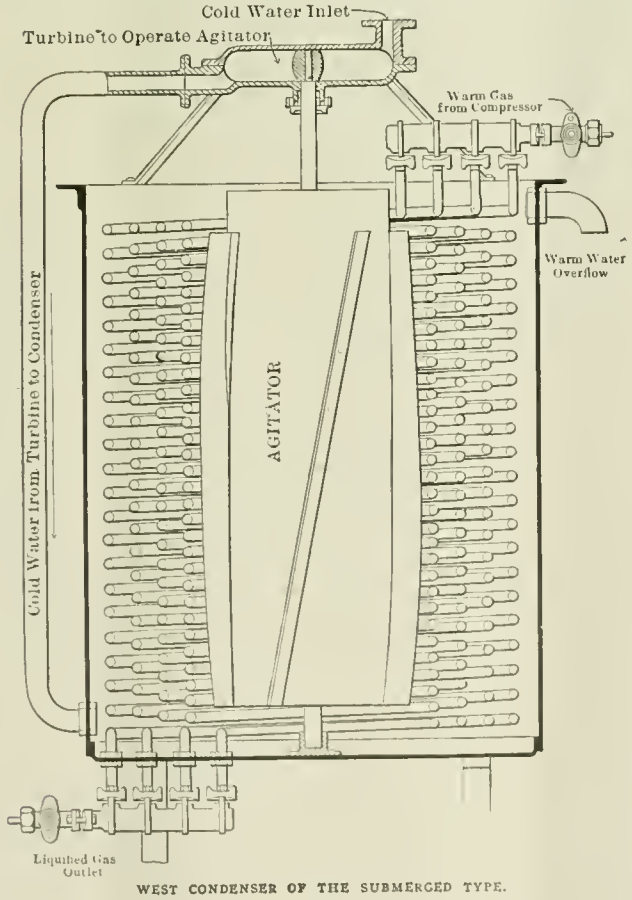
separate cooling apparatus and separate fans must be used, if the air returns from the chambers to the cooling plant. The case may be met by the adoption of what electricians would call the parallel system. One supply of air could be employed, and one cooling plant, and one fan, the air for the different chambers being directed into separate ducts and then discharged into the atmosphere from the chambers; but care must be taken, if this plan is adopted, that the air which passes out of the chambers does not get to the shaft from which the inlet air is taken.



HASLAM AMMONIA MARINE REFRIGERATOR, WITH COMPOUND ENGINE AND COMPRESSORS.

THE DOORS OF COLD CHAMBERS.

The doors of cold chambers are very important. They must be constructed on the same lines as the chambers themselves.



WEST CONDENSER OF THE SUBMERGED TYPE.

When a door is closed it must form part of the wall of the chamber into which it fits, in the sense that it excludes the heat, just as much as the chamber wall proper does. In ship work the difficulty is, as with so many other things, to find room for proper doors. The thickness of the doors should be the same as that of the walls; and as far as practicable, they should be built in the same way, of two lots of matched boarding, facing each other, lined with waterproof paper on their inside faces, and the space filled with an insulating material. The door itself also must be made to fit air tight into the doorway. There must be no cracks, such as we are accustomed to in the doors of our living rooms, and no spaces between the door and the wall, when the door is closed. Further, the door must be pressed home firmly when closed, and the fastening be such that it cannot easily work loose, even in a heavy seaway.

When the cold chamber is in use the door should be opened as infrequently as possible, and then closed immediately; for every time a door is opened, as already explained, heat is admitted to the chamber, which means more work for the machines. On shore, wherever it can be arranged, double doors are fixed, the outer being closed before the inner is opened, so that only the small lobby full of air from outside is admitted.

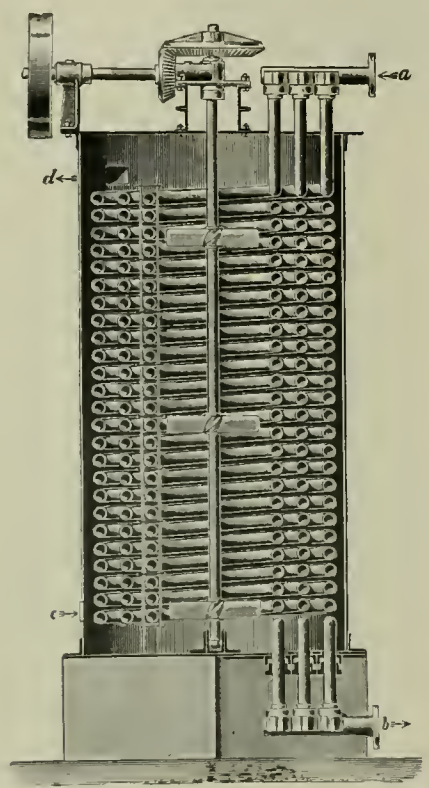
HOW THE LOW TEMPERATURE OF THE BRINE OR REFRIGERANT IS PRODUCED.

The operation of one method, that of alternately compressing air and allowing it to expand, has been described. The other method, of which there are two variations, has been partly indicated. A refrigerant, ammonia, carbonic acid or sulphurous acid, these solutions lending themselves peculiarly to this work, is caused to assume alternately the liquid state, and the gaseous state. In expanding from a liquid to a gas, it abstracts heat from the brine, the air of the chamber, etc., as has been shown. To accomplish this, and to work economically, a circuit is formed, consisting of the compressor or its equivalent, as will be described, the condenser, the expansion coils, and the connecting pipes. The compressor is practically a pump. After the refrigerant has done its work, and become a gas, it is sucked back into the compression cylinder, compressed, and then forced into the condenser, passing thence to the expansion coils and back to the compressor.

The latter consists of one or more cylinders in which pistons work, very much on the lines of steam cylinders, but with certain modifications. There are one or more suction valves to each compressor, and one or more delivery valves. The cylinders may be either single or double acting. If single acting, gas is taken in on one stroke and compressed on the return stroke, something on the lines of the old Cornish single acting engine, but with the operation reversed. When double acting, gas is taken in at each stroke, and compressed at each stroke, the rear of the piston performing the office of suction, while the front compresses. The valves are all of one type, shaped like the frustum of a cone, seated in extensions of the cylinder covers and kept

on their seats by spiral springs, which allow them to open inwards or outwards, as the pressure is reduced or increased sufficiently to allow the spring to operate in the case of the suction valve, and to overcome the spring in the case of the delivery valve. The piston also is slightly different from the ordinary steam or compressed air piston.

Marine engineers are well acquainted with the evils of clearance in engine cylinders. With compressors used for refrigerating apparatus the trouble is very much increased, because the small quantity of the gas remaining in the cylinder, in the clearance space, is in a highly compressed form, and immediately it is released by the return of the piston, expands, occupying the space left vacant, and introducing a pressure against the ingress of the next lot of gas, thus reducing the quantity taken in on the suction stroke. To obviate this, nearly all compressors are made with the ends of the cylinders dome shaped, and the ends of the pistons hemispherical, or as nearly so as they can be made, so that they run very close up to the cylinder end. One firm in



SUBMERGED CONDENSER.

a AMMONIA INLET. *c* WATER INLET.
b. AMMONIA OUTLET. *d*. WATER OUTLET.

the United Kingdom uses a flat cylinder end, a flat piston, and provides a spring which is compressed as the piston moves up to the cylinder end, the spring taking the thrust, keeping the piston away from the end of the cylinder, and helping to start it back on the return stroke.

The De La Vergne Company of New York employs another method. A small quantity of oil is injected into the cylinder, shortly before the end of the stroke, and the oil and gas are ejected together, the refrigerant being freed from the oil by a separator before being used again. The delivery valves open automatically when the pressure inside the cylinder on the compression side of the piston is sufficient to overcome the tension of the spiral spring, and close immediately when the pressure is reduced sufficiently for the spring to overcome it; the suction valve doing the same, in the reverse direction.

Compressors for refrigerating machines are often made compound. The compression is completed in two cylinders, there being sometimes an intercooler between the two. The gas is compressed to a certain pressure in one cylinder, and the complete pressure obtained in the second. It is the reverse operation to that of a compound engine. In the act of compression the gas is made to take up a smaller volume, and becomes heated, just as air does in compression. It is necessary to compress the gas in order to enable it to be liquefied with a reasonable quantity of cooling water. The molecules of the gas are brought closer together, and are then more ready to take on the liquid form. But in order that the gas may become a liquid, the heat of compression, as well as the latent heat of the gas, must be removed. Further, as it becomes heated it tends to expand, and to occupy a greater space than it would otherwise do, and than it will do when the heat is removed. It is for this reason that the intercooler, where compound compression rules, is so valuable. By removing the heat of compression of the first cylinder, the volume entering the second cylinder is smaller for the work that is to be accomplished. Besides, the heat generated would otherwise act upon the cylinder itself, and if allowed to become too great, upon the valves.

When the compression cylinder is hot the gas entering at the suction stroke is heated and expands, and the weight that is taken in at each stroke is lessened, so that the efficiency of the apparatus is thereby reduced, for more work has to be done by the compressor for the same refrigerating effect. There are several methods of dealing with this matter. One has already been referred to, that of the De La Vergne Company. The oil which is injected into the cylinder to fill the clearance space also cools the cylinder itself, by absorbing some of the heat. Another method is what is termed the "wet compression." A small quantity of liquid refrigerant is allowed to pass into the compressor, with the gas. On its entrance into the cylinder, it expands to the gaseous state, absorbing some of the heat of the cylinder walls, etc. One objection to this is that it is difficult to arrange it properly, and its effective operation must depend upon the attendant.

The cooling is effected in the expansion coils by the passage of sufficient liquid refrigerant into them, to absorb the heat that is to be taken away. Any additional quantity of liquid refrigerant that is allowed to pass through lowers the efficiency of the machine, as it has to be handled without giving back any useful result. On the other hand, cooling the cylinder by the aid of the refrigerant adds to the efficiency. It is again a case of the balance sheet. Another method is the well-known one employed with gas engines, of circulating cooling water in a cylinder jacket. Double acting compressors heat more than single acting, as will be easily understood, and for that reason many engineers prefer single acting apparatus.

(*To be continued.*)

THE NEW TRAFALGAR GRAVING DOCK AT SOUTHAMPTON.

Southampton is in course of becoming one of the most important ports of England. In 1892 the tonnage entering this port was 2,369,642 tons gross, while in 1904 this tonnage increased to 5,693,642 tons gross, and this year will be more important, as now a very large part of the American import and export trade passes through Southampton, which has for speedy loading and discharge of vessels every appliance necessary to make it a first-class port.

In the beginning of 1901, after having just opened a fifth dock, the London & Southwestern Railway decided on the construction of a sixth capable of receiving the largest vessels in the world. This dock was commenced in August of the same year, and was opened on October 21 last. Its cost was about $1,500,000, equipment included, and all three dimensions taken into consideration, it may be reckoned as the greatest in the United Kingdom.

Its main dimensions are:

Length from joint of sill to dock-head..... 875 ft., 3 in.
Length occupied by keel-blocks..... 839 ft.

Width of entrance	90 ft.
Width of dock at floor level	90 ft.
Width of dock at cope level	125 ft.
Depth of dock from cope to floor	43 ft.
Depth of water over sill at high water of ordinary spring tides	33 ft.
Depth of water over sill at high water of neap tides	29 ft., 6 in.
Depth of water over keel-blocks	6 in. more than over sill.

The dock has been constructed on made land; the area has been inclosed with a chalk dam, and chalk was utilized in foundation work. The excavation for the dock involved the removal of 226,200 cubic yards of material. Some 133,000 cubic yards of Portland cement concrete have been used for the floor, altars and walls, which are entirely built of this material. The bottom of the dock is curved, the maximum thickness being, of course, at the center, where the upward thrust will be the greatest. Here, it is 16 feet thick. The side walls are 22 feet 6 inches at the base, diminishing to 3 feet at the coping. There are seven altars, 2 feet 6 inches wide and 2 feet 9 inches high. Access to the bottom of the dock is afforded by eight flights of steps, while there are four timber slides. The keel-blocks are all of oak with elm caps. The sill is formed of granite, and the gates have been constructed entirely of steel. The entrance gates are covered by greenheart timber meeting faces, and 250 tons of steel are contained in each gate. The gates are opened and closed by direct-acting hydraulic rams, operating through a suitable crosshead, and a build-up lever attached to the rear of the gate. When opened, they lie in a recess formed in the entrance walls, with timber fenders.

The powerhouse for the dock is a very capacious building, including, in the center, the steam generating plant, at the upper end the electric machinery for running the motors and lamps throughout the whole dock estate, and at the lower end the pumping plant, including two 48-inch pumps, driven by powerful two-cylinder engines. There is a large condenser for these and the electric generating engines. Separate auxiliary machinery, consisting of airpumps and circulating pumps, is installed. It is anticipated that the main pumps will discharge the water from the dock (85,000 tons) in about 2½ hours. There is further a 12-inch centrifugal pump for dealing with any water that may leak into the dock from time to time. The steam plant consists of seven locomotive boilers. These are sufficient to run the electric lighting plant as well as the main pumps. There are six sets of compound inclosed high-speed engines, driving 75-K. W. generators. The distribution is on the three-wire system. Included in the equipment of the dock is a very powerful electric crane, shown in our illustration, which has a capacity of 50 tons at a radius of 87 feet, or at the center line of any ship in the dock, and which travels the whole length of one side of the dock. E. O.

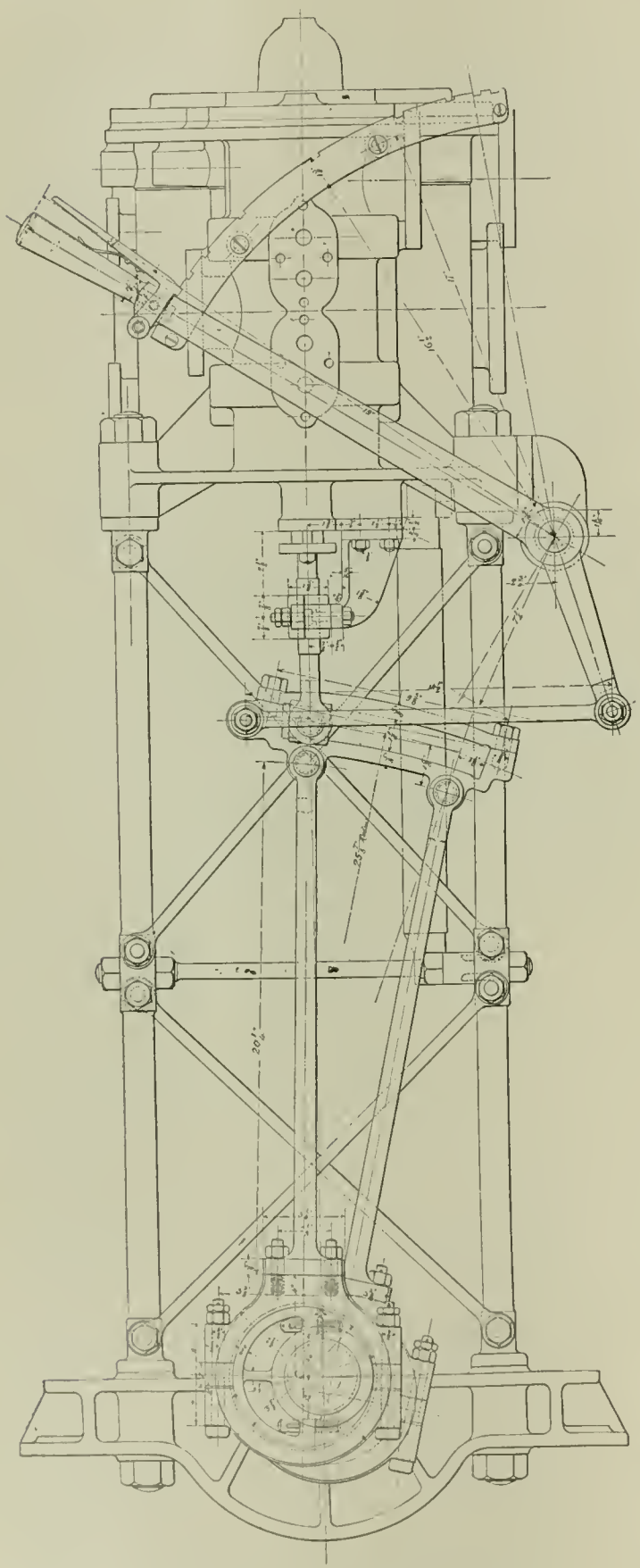
A VIEW OF THE TRAFALGAR DOCK, EMPTY OF WATER, SHOWING FIXED KEEL BLOCKS.

A COMPOUND ENGINE DESIGN.

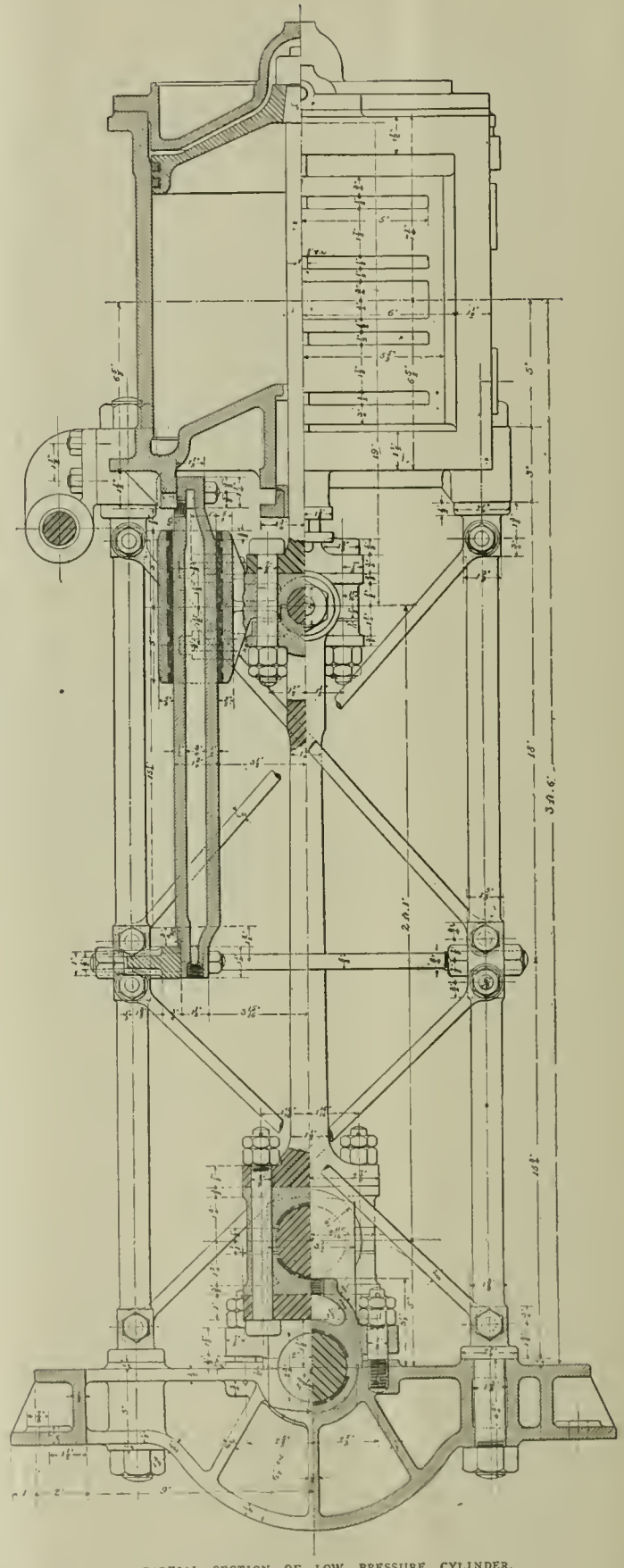
Numerous requests have reached us for specific information regarding the design of marine engines of various sizes and characters. We are enabled to present in this issue drawings of such an engine design, by Henry J. Gielow, the drawings showing a great deal of detail, and being, in fact, actually working drawings from which the engine was constructed.

This engine was built for the Quartermaster's Department of the United States Army, about a year and a half ago, being fitted in a steamer measuring 60 feet 0 inches on deck, 53 feet 3 inches on the load line, with a beam of 12 feet 2 inches, a molded depth of 6 feet 6 inches and a load draft of 4 feet 3 inches. The engine was designed to develop about 100 horsepower, corresponding with a speed of 12.5 statute miles per hour. Both power and speed were exceeded on trial, the engine having been worked up to 125 horsepower, while the most efficient operation appeared to have been at about 80 horsepower.

As shown on the drawings, the engine is compound, with cylinders 6 and 12 inches in diameter and a common stroke of 10 inches. The high-pressure cylinder is fitted with a piston valve 3¾ inches in diameter, while the admission and discharge of steam from the low-pressure cylinder are governed by a double ported D slide valve. The steam port on the high-pressure cylinder has an area of 4.38 square inches, and exhaust port 4.9 square inches; on the low-pressure cylinder these areas are respectively 9.5 and 11 square inches. The cylinder barrels have a thickness of ⅝ inch, and are made of close grained cast iron, bored and with a counterbore of 3-32 inch at each end. The lower



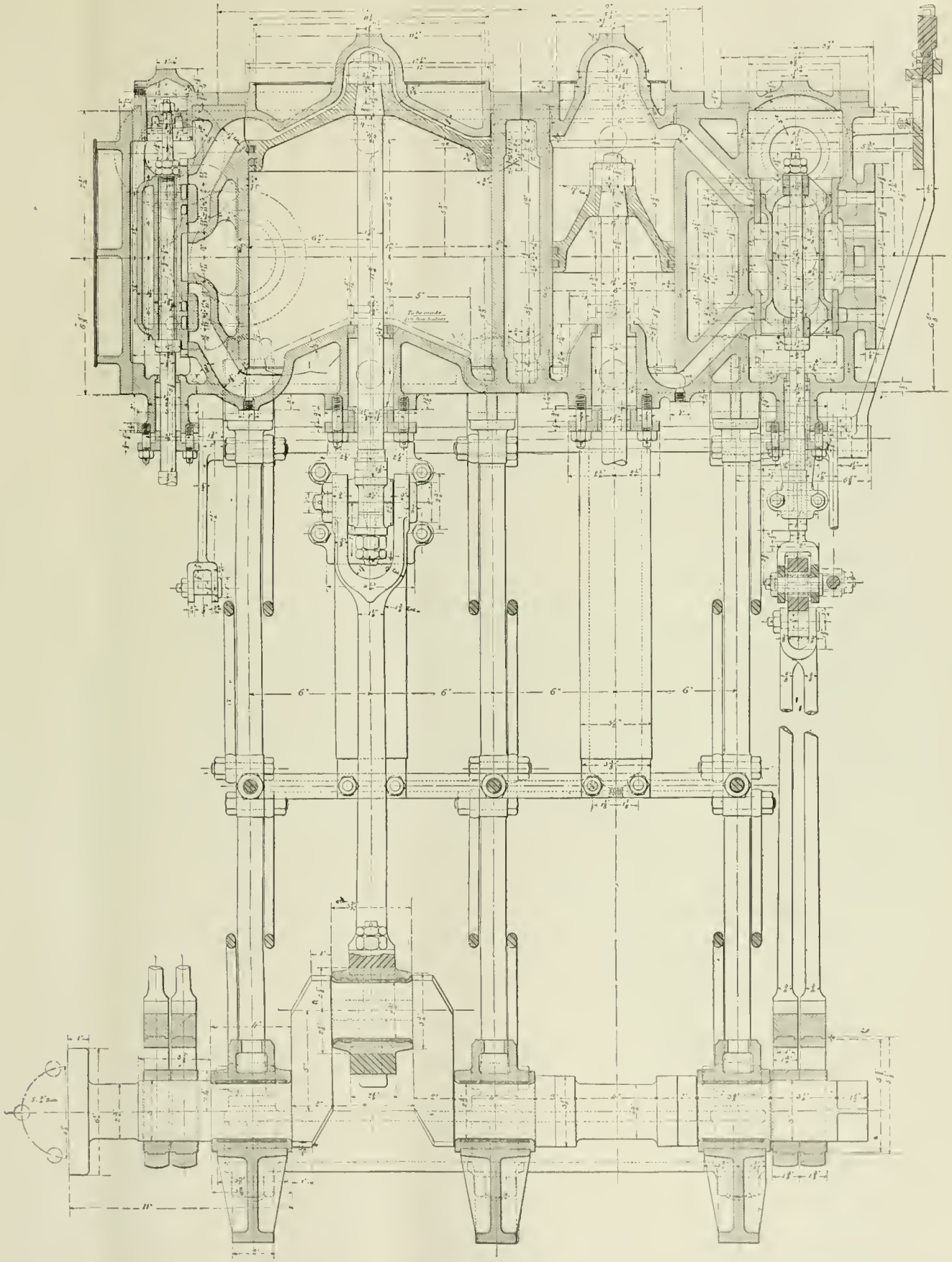
END ELEVATION OF ENGINE, FROM FORWARD.



PARTIAL SECTION OF LOW PRESSURE CYLINDER.

heads are fitted with stuffing box and gland with metallic packing, while the upper heads are conical, with central hoods to accommodate piston nuts.

The main frame of the engine consists, as shown, of six steel columns 1¼ inches in diameter, with three transverse tie rods ⅝ inch in diameter and two longitudinal ties of T section.

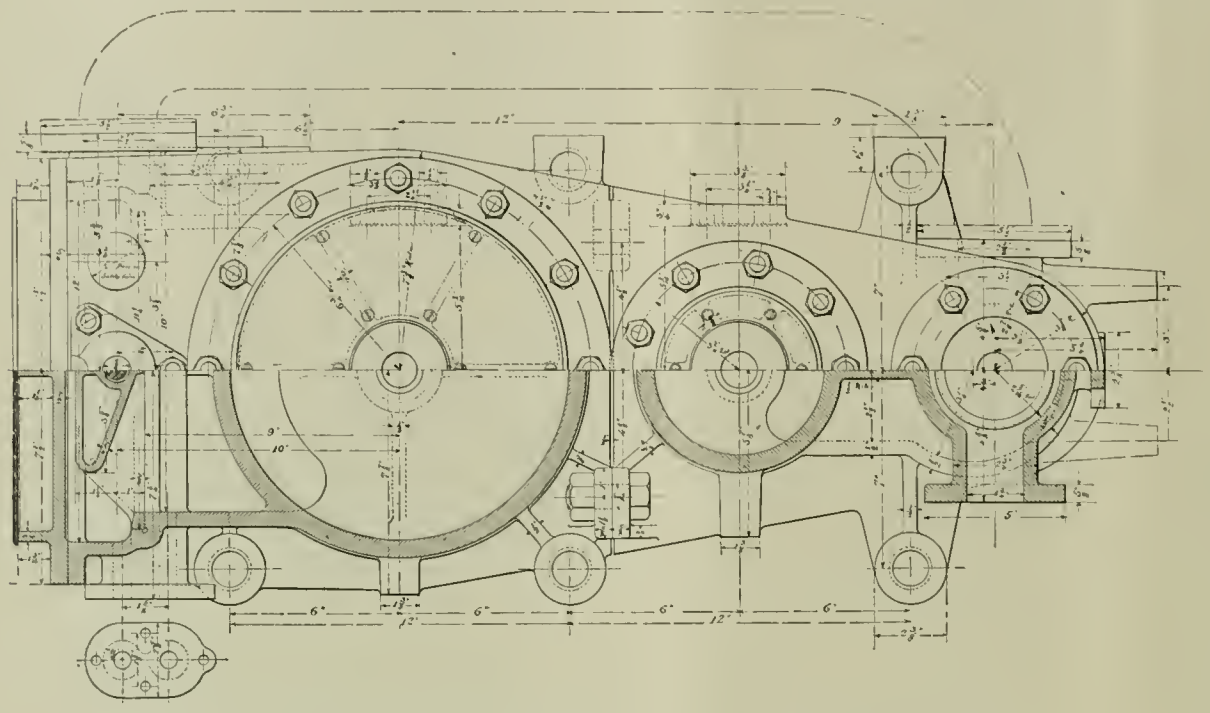


LONGITUDINAL SECTION OF THE ENGINE, SHOWING THE VALVE ARRANGEMENT AND DETAILS.

There are also twelve diagonal braces, ½ inch in diameter, fitted as shown on the drawings.

The valves are worked by Stephenson link motion, with single bar links having a throw of about 6 inches, there being two

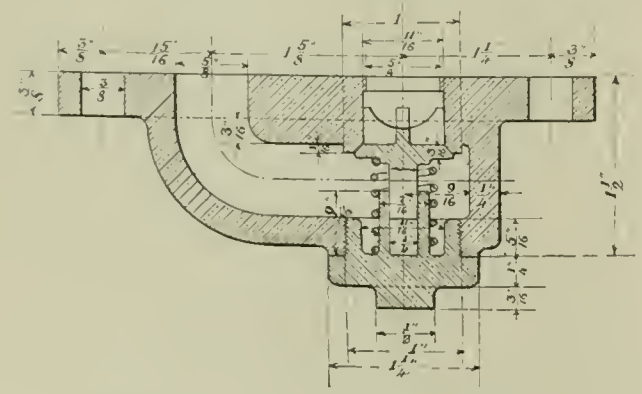
eccentrics to each link. The eccentric rods are of forged steel, the ends connecting with the straps having a T head forged on to bolt to straps. The link ends of rods are forked for connection with the link. Eccentric straps are of composition.



PLAN VIEW OF ENGINE, HALF IN SECTION, SHOWING COMPACT ARRANGEMENT OF CYLINDERS.

The pistons are single shell, of cast steel, and fitted with hard cast iron packing rings with customary tongue piece. Piston rods are forged steel, 1¼ inches in diameter, with taper fit to piston and forged T ends for crosshead connection. They are secured to pistons with steel nuts and pins, and to crossheads with steel bolts and nuts.

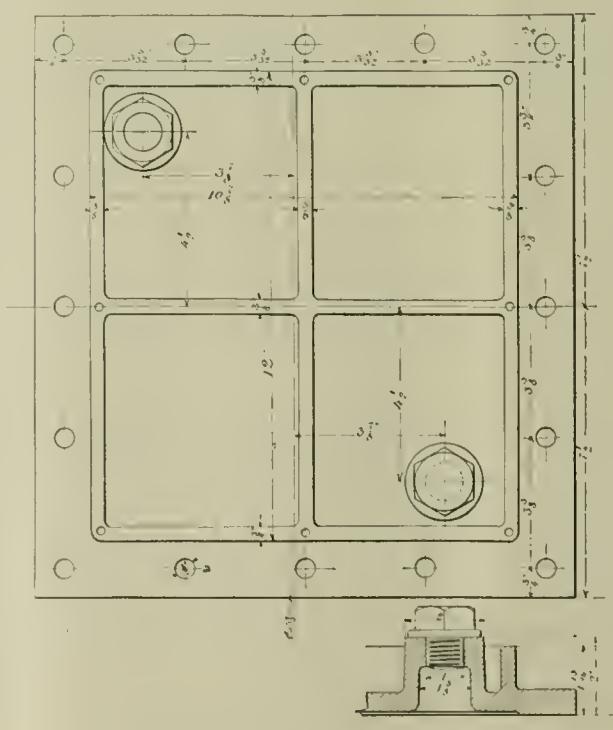
The crossheads are made of bronze in two pieces bolted together, each having a journal 1½ inches in diameter and 2¼ inches long. The wearing surfaces of crosshead slippers are about 21 square inches each. Crosshead guides are of box section, of hard cast iron, with face 3½ inches in width and 1¾ inches thick.



SECTION OF THE HIGH PRESSURE RELIEF VALVE.

The connecting rods are of forged steel forked at the crosshead end, and fitted with T at crank end. They are about 25 inches long between centers, and furnished with composition boxes around the crank pins. The rods have a diameter of 1¼ inches at the upper end and 1½ inches at lower.

The crank shaft is of forged steel, with two cranks set at an angle of 90 degrees; crank arms have a thickness of 2 inches and width of 3½ inches; crank pins are 4 inches long and 2¾ inches in diameter; main bearings have a diameter of 2¾ inches, and a length of 3⅝ inches for the forward journal and 4 inches for each of the others. The crank shaft pillow blocks have caps of bronze, lined with white metal, and held in position by six steel ⅞-inch bolts, two in each bearing.

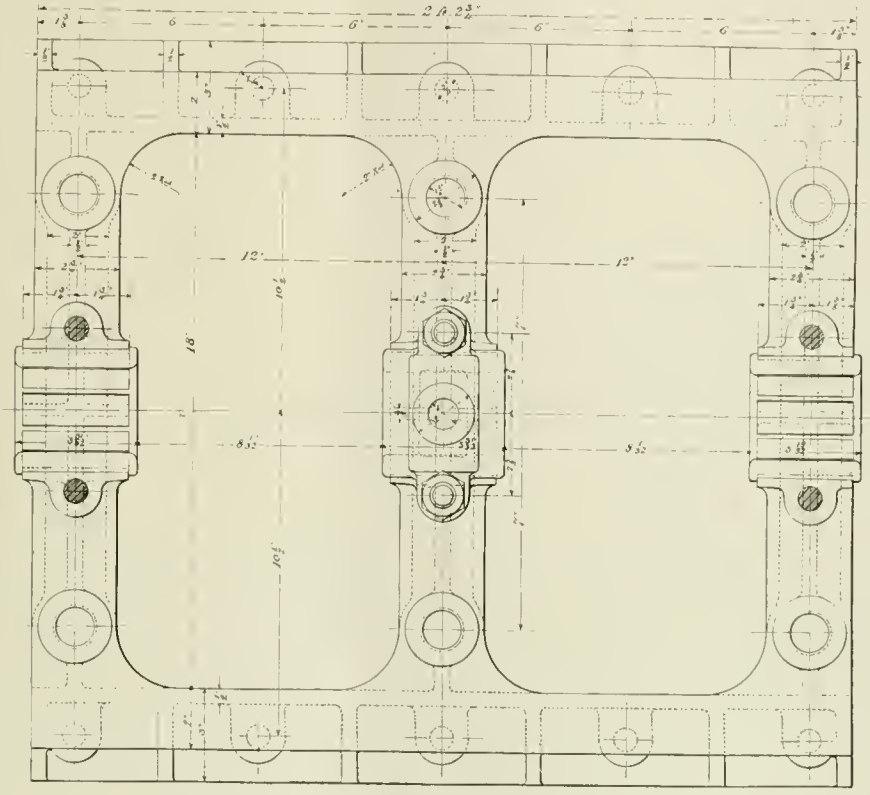


LOW PRESSURE VALVE CHEST COVER AND DETAIL.

The line shaft is made in two lengths, the forward section, or thrust shaft, being of forged steel 2¾ inches in diameter,

while the after section, or tail shaft, is of tobin bronze 3 inches in diameter. The couplings are forged on the shafts, disks being fastened together with six ⅞-inch steel bolts. The disks have a diameter of 6¼ inches. The tail shaft has a length of 9 feet 6 inches, and the thrust shaft of 7 feet. The thrust bearing is near the forward end of line shaft, and is of the usual collar type, with proper connection to the oil reservoir for lubrication.

Steam is furnished by a water tube boiler 5 feet 6 inches long, 5 feet wide and 5 feet 4 inches high, with a grate surface of 17.4 square feet and a heating surface of 515 square feet.

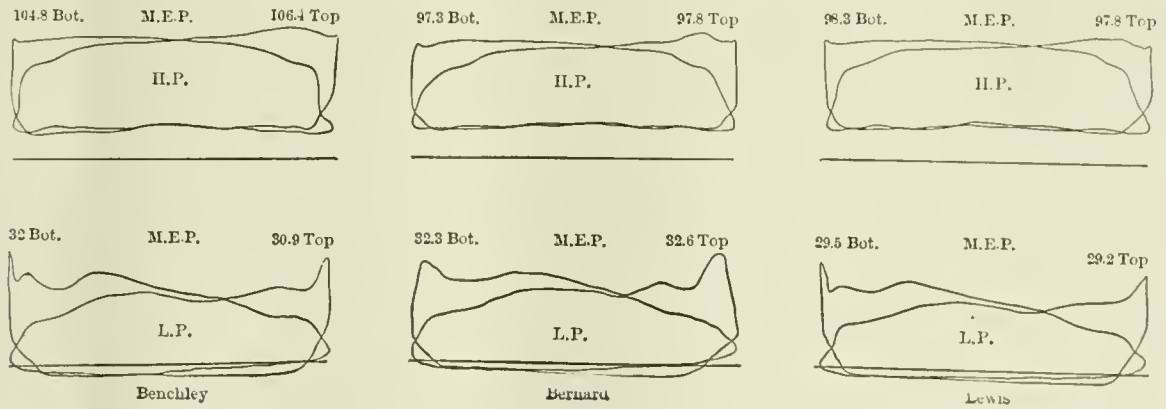


BED PLATE OF ENGINE, SHOWING THE THREE MAIN BEARINGS.

made unduly heavy. The operation is reported to have been very smooth in every respect, and the engine appears to represent an extremely "healthy" type of engine for the power required.

TRIAL.

Three of these engines were fitted respectively on the United States steamers *Lieutenant Lewis, Lieutenant Bernard* and *Lieutenant Benehley.* We have been given indicator cards from these three steamers, together with data covering the tests, and

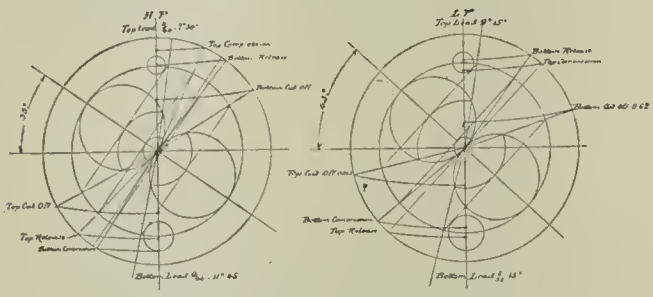


SAMPLE INDICATOR CARDS FROM THREE ENGINES BUILT FROM THIS DESIGN.

The designed working pressure of the engine was 250 pounds, although it was expected that operation would be usually at 175 pounds per square inch. All of the parts, however, were proportioned for the higher pressure. This engine, having been built for steady and heavy service under Government specifications, has shown itself thoroughly well adapted to the work which it has been called upon to perform, there having been no attempt to cut the weight below the figure which would give ample strength for all purposes, and on the other hand no part is

are informed by the Quartermaster General of the War Department that on each of the trials the engines ran smoothly and without heating in any of the bearings, although driven to maximum speed for over four consecutive hours with valves in full gear, throttle wide open and boiler at full pressure. Each launch has a three-bladed propeller consisting of solid casting of composition and having a diameter of 42 inches, pitch 48 inches, developed area 698 square inches, projected area 556 square inches. The disk ratio, or ratio between projected area and the area of

the circle swept by the tips of the blades is 0.402. A pitch ratio of 1.14 results from the relation between diameter and pitch.



VALVE DIAGRAMS, HIGH AND LOW PRESSURE.

	Benchley	Bernard	Lewis
Steam pressure	178lb	175lb	171lb
Receiver pressure	40lb	43lb	43lb
Vacuum, inches	15.25	16	14.75
M. E. P., H. P. cylinder	105.6	97.55	98.05
L. P. "	31.45	32.45	29.35
I. H. P., H. P. "	52.3	47.	48.5
L. P. "	63.4	63.6	59.
main engine	115.7	110.6	107.5
auxiliaries	8.	8.	8.
Revolutions per min.	355.	345.	354.
Miles per hour	(a)13.45	(b)12.	(b)11.84
Pounds coal per hour	185	185	170

a With the tide. b After eliminating current.

STEAMING ECONOMY OF U. S. S. MARYLAND.

BY H. C. DINGER, U. S. N.

The *Maryland* is a large armored cruiser of 14,000 tons displacement; designed horsepower 23,000, speed 22 knots; horsepower developed in service 27,500, speed 22.5 knots. Her installation of machinery consists of two sets of four-cylinder triple expansion engines, with cylinders 38½, 63½ and two of 74 inches diameter, all with a stroke of 48 inches. All cylinders are steam jacketed. The low-pressure cylinders are at the ends, with the high and intermediate in between. All valves are of the piston type. There are sixteen Babcock and Wilcox watertube boilers, safety valves set at 285 pounds, total grate surface 1,600 square feet. Feed water heaters which use the auxiliary exhaust steam as the heating agent, are installed, one in each engine room.

The installation may be taken to represent the latest practice with reciprocating engines, and hence the economy obtained under various conditions may be of particular interest. The following are some results obtained in practice:

Boilers.	Revs.	I.H.P.	Speed.	Coal per I.H.P.	Coal per day
16 Nat.	106.5	15,395	19	1.74	(a) 288 tons
6 F. D.	95.5	10,520	17	1.74	(a) 183 "
10 Nat.	90	8,444	16	1.71	(a) 155 "
8 Nat.	82	6,736	15	2.08	(b) 50 "
6 Nat.	74	5,422	14	1.95	(c) 114 "
6 Nat.	64	3,152	12	2.3	(c) 79 "
4 Nat.	62	3,232	11.2	2.04	(a) 71 "
4 Nat.	56	2,634	9.5	2.32	(a) 65 "
16 F. D.	127.5	27,102	22.5	2.3	(b) 669 "
16 F. D.	127.8	27,571	22.4	2.95	869 "

(a) New River, (b) George's Creek, (c) Eureka.

The figure "coal per I. H. P." given above is obtained by dividing the total number of pounds of coal burnt for all purposes, including lighting, distilling, etc., by the I. H. P. of the main engines. By taking away the amount of coal used for auxiliaries, and then dividing by the horsepower of main engines, results below 1.6 have been obtained when running at 84 revolutions. The last line gives the figures of coal consumption on the official trial trip.

While in company with other ships of her class, the *Maryland* has shown a very perceptible advantage in coal economy. It is natural to suppose that there are reasons why this greater economy is present. The following is a recital and description of the various methods used in striving for this result. The methods are not new, but are in general a thoroughly practical application of matters that have been previously pointed out in both theory and in practice; but which, on account of not being thoroughly understood, are not carried out in practice by many practical marine engineers.

The first element to deal with in attaining economy is the boiler plant. Economy here depends upon (1) The design and arrangement of boilers. (2) The care exercised in keeping the boilers clean and in thorough repair. (3) Efficient firing.

BOILERS.

The boilers are of the latest Babcock and Wilcox type. They are accessible on all sides, and have roomy firerooms. These conditions make it possible for them to be well taken care of without any great amount of difficult labor. They are arranged so that they can be cleaned of soot while steaming, and in port they can be thoroughly cleaned with comparatively little trouble. In this particular this vessel has an advantage over some of her sister ships, whose boilers can not be as readily cleaned.

The sister ships in squadron are the *West Virginia* and *Maryland*, built by the Newport News Shipbuilding and Dry Dock Company, fitted with Babcock and Wilcox boilers; and the *Pennsylvania* and *Colorado*, built by William Cramp and Sons, fitted with Niclausse boilers.

The following rules are established on the *Maryland* for firing boilers, and for their routine care and management:

ORDER FOR THE OPERATION OF THE BOILERS.

The general routine for procedure in the boiler rooms is to be strictly followed while boilers are under steam. In addition, the following rules are to be adhered to:

FIRING.

Coal will be thoroughly broken up and lumps no larger than the fist will be put into the furnace. Furnace doors will be opened just as little as possible. Furnaces will be fired in regular rotation, and must not be choked near the furnace doors. No more than five shovels full of coal will be put into one fire at one time. The fires will be pushed well back from the furnace doors, and the dead plates will be kept absolutely clear of coal. Slicing will not be done until absolutely necessary to break up the clinkers.

Unless otherwise directed, tubes will be swept with steam by the watch that relieves the watch that has cleaned the fires. The chief water tender will give directions as to the time of cleaning fires, and will be responsible for their proper condition.

When burning about 20 pounds of coal per square foot of grate per hour, fires will be cleaned every 24 hours. Fires will not be carried over 7 inches thick, as per aluminum paint mark inside the furnace door. The fires will be carried level over the entire grate. Just before time for firing the furnace, the fire will be raked over with a small hoe, and at time of firing, the coal thrown evenly all over the fire.

Boilers will be blown with slight surface blow first, then a slight bottom blow every day at 7 p. m. The water tender on watch will be responsible for carrying out the order. One pound of soda or lime will be put into the feed tank at every morning watch for every boiler in use. Machinist on watch will see this done.

As soon as the fires are out, unless under special order to the contrary, on account of repairs, etc., boilers will be given first a surface and then a bottom blow, and afterwards pumped full of fresh water well up to the upper gage cock, to insure water level being well above the opening of the upper tubes. As soon as fires are allowed to die out, and the boiler is cool, the fire sides of boilers will be thoroughly cleaned of soot. The

grate surface will be overhauled, leaks repaired and the boiler in general put in shape for steaming when needed.

ORDERS FOR FIRING BOILERS.

Whenever in steaming watch, furnaces will be fired in regular order as numbered. Each fire will be leveled immediately after the furnace two numbers ahead is fired. Thus, when No. 2 is fired, No. 4 will be leveled, when No. 3 is fired, No. 5 will be leveled, when No. 4 is fired, No. 6 will be leveled, and so on. If more or less coal is to be burnt, the firing interval will be changed, firing oftener or less frequently, as required. With one inch air pressure, a furnace should be fired each minute; with natural draft, about each minute and a half.

Cleaning Fire Sides.—Special care is taken to thoroughly clean the fire sides whenever fires are allowed to die out. The usual method is to loosen up the soot with hand brushes through the cleaning doors, and to haul out the accumulation of soot from above the horizontal baffle. Then put on forced draft, about 2 or 2½ inches pressure on the boiler compartment, open ash pans and dampers and assist the loosening up of the soot by means of the steam lance through the dusting doors. In this way all the dirt is driven up the smoke stack, and the fireroom is not dirtied to any great extent. The fire sides of boilers are very thoroughly cleaned in this way.

Whenever boilers are used for any extended period underway, the tubes are swept with the steam lance through the dusting doors at regular intervals. Under forced draft and with proper light, smokeless fires practically no soot collects. Therefore we see here a most important reason for keeping fires from smoking. The keeping of fire sides of tubes thoroughly clean is a most important item for obtaining the economical performance of boilers.

Care and Cleaning Water Side.—The main points under this heading can be seen by noting the instructions. They are, namely, regular use of surface and bottom blow every day, a regular supply of soda, special care in keeping air out of boilers, and the maintenance of clean fresh feed water. The soda is added to keep the oil from depositing in the tubes, and the blowing to get rid of the oily scum at surface and the accumulation of dirt at bottom.

The regular use of cylinder oil is prohibited, and a grease extractor is fitted on dynamo air pump discharge and filter boxes on the feed tanks. But in spite of these precautions some oil finds its way to the boilers, and collects on surface of tubes. To remore this oil deposit the boilers are either boiled out or cleaned with turbine cleaner.

To boil out: the boiler is opened, about 20 gallons of kerosene and 30 pounds of caustic soda for every 100 square feet of grate surface are put into the boiler, which is closed and filled to lower part of drum with water. A small steam connection is made to the bottom of boiler, then steam is turned on, the water is caused to boil at about 50 pounds pressure for several days, the boiler being in the meanwhile given a surface and bottom blow periodically. When boiling is finished, boiler is given first a surface blow and then entirely emptied. This process of boiling removes the deposit, or causes it to become dry powder, which can be washed out.

Cleaning with turbine: the deposit of oil and dirt may become so thick that boiling will not remove it properly. Then recourse is had to the turbine cleaner, which instrument completely removes all deposit. This cleaner is operated by a hose led from one of the auxiliary pumps. The turbine is inserted in the tube and water pressure put on. The turbine revolves at high speed and the arms carrying the cutters press out against the sides of the tube and remove all deposit. The turbine is hauled back and forth through entire length of tube until clean. The water, on leaving the turbine, washes out the loosened sediment, and carries it out of the ends of the tubes.

Firing.—By the system of keeping light, regular, thin and smokeless fires as described in the instructions, and by avoiding slicing as much as possible, all the coal is actually burned. The avoidance of smoke is most important; first, by reason of smoke being a direct loss as unconsumed fuel; second, because smoke causes the collection of soot on the tubes, thus rendering their heating surface less efficient; third, because smoke is a cause of much dirtiness of decks, boats, guns, etc.; fourth, because much smoke is undesirable for military reasons. A smokeless fire means cleaner heating surface, and hence greater boiler economy. Continual and unnecessary slicing results in great waste of fuel, as particles of coal are continually dropping into the ash pans. In order to attain economy slicing must be avoided as much as possible.

HANDLING OF HEAT.

Having obtained steam at the boilers with the least expenditure of coal, the next problem for securing economy is to handle the heat units thus secured in the most efficient manner.

Jackets.—The first item is the use of steam jackets. Jackets are used constantly. The pressure in intermediate and low-pressure jackets is maintained at a pressure above that of the steam in those cylinders. That in the high-pressure jacket is kept at about 150 to 200 pounds. This lower pressure is used to avoid excessive heating of the walls of the high-pressure cylinder. Such heating would cause the steam to become very dry, and this would bring about difficulties in lubrication, excessive friction and cutting and scoring of cylinder and valves.

Adjustment of Links.—The next item to consider will be the adjustment of the links of the valve gear. To secure the greatest economy, the steam should be expanded as many times as possible. Hence the high-pressure cutoff, which regulates the rate of expansion is always made as early as possible, provided the desired number of revolutions can be made with the steam at working pressure of boilers. When more speed than this is required, the cutoff is run out just sufficient to obtain the necessary revolutions.

In this way the greatest range of expansion under any and all conditions is obtained, and hence the most economy, from the principle of expansion, is secured. This regulation of the links is of extreme importance in securing economy, and is a matter that is not, as a rule, properly understood; for this reason the position of cutoff is very often not looked at at all, or else the cutoffs are adjusted in a manner that will not secure the highest economy.

For example, let us suppose the vessel is running at low power, say one-third power, ratio of low-pressure to high-pressure piston is 7.5, and under condition *A*, the high-pressure cutoff is set at 0.6 stroke, steam at high-pressure chest 175 pounds. Under the other condition *B*, the cutoff is all the way in, at 0.45 stroke, steam pressure at high-pressure chest 240 pounds. The number of expansions for condition *A* is 12.5, for *B*, 16.6. The expected steam consumption for *A* is 15.4 pounds of water per horsepower per hour; for *B* it is 14.3 pounds of water per horsepower per hour. The above pressures for steam at high-pressure chest are the pressures necessary to secure the same revolutions under the two different positions of high-pressure cutoff.

The above figures for steam consumption are taken from tables of expected mean effective pressure, assuming 65 percent card effect; and the pressure at high-pressure chest and expansions as given above.

In the above case the changed conditions produced an increase in economy of 7 percent, and in actual practice a similar result is effected.

Vacuum.—The next point in the handling of the heat is in securing the highest possible vacuum. The air pump must be continually watched, and when less than 27 inches is shown, the reasons for this drop ascertained and remedied. The pump must be kept constantly in good condition, and the exhaust piping absolutely tight.

In the regulation of the circulation pump, a temperature of

discharge below 100 degrees Fahrenheit must be maintained, to secure a vacuum of 28 inches. With very hot circulating water, above 80 degrees, it may, however, be impossible to obtain a vacuum above 26 inches. The maintenance of high vacuum is most essential to secure economy. It is something very often overlooked or carelessly regarded, many engineers being satisfied with 24 inches of vacuum, when by more care and oversight 27 inches could be obtained.

Hot Feed Water.—We have now come to the most important item of all. By the use of what up to a few years ago was ordinarily waste heat in marine practice, such as trap drains, vapor from evaporators, and the heat of the auxiliary exhaust steam, a temperature of feed water reaching 200 degrees and above can be maintained.

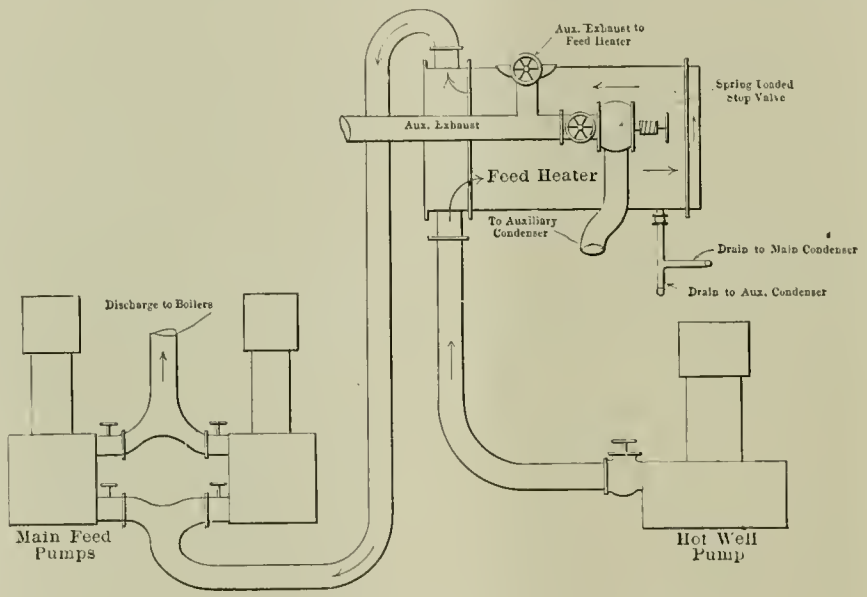
The evaporators are usually worked in double effect, and when so operated are arranged so that the drain from the low pressure evaporator coils, which is the steam made in the high-pressure shell, is led to the feed tank direct as make-up feed, instead of being led to the distillers. The heat contained in the drain water is thereby saved, instead of being lost in the distiller circulating water.

their actual consumption of steam but slightly. When the exhaust steam is used to heat up the feed water, instead of being led to the condenser, the latent as well as the sensible heat it contains is absorbed by the feed water, and is thus saved and retained in the system.

The saving by heating feed water to 200 degrees F. by auxiliary exhaust at two or three pounds pressure, over the practice of running auxiliaries on a vacuum with no feed heater, is fully 10 percent in actual practice. Aside from this, hot feed water is much easier on the boilers. It is not believed to be advisable to keep a greater pressure than 5 pounds on auxiliary exhaust, on account of the increased loss of water from leaks in the auxiliary exhaust system.

The system of feed water heating on the *Maryland* may be made plain by the description and accompanying sketch.

The auxiliary exhaust is led to a closed feed water heater. This heater consists of a shell and a nest of tubes, the feed water circulating through the tubes as indicated. The steam is on the outside of the tubes. The feed water is pumped through the heater by means of the hotwell pump, which draws from the feed tank, and the water discharges, after leaving the heater, to



LAYOUT OF FEED WATER HEATING PLANT ON MARYLAND.

The evaporators are also arranged so that the vapor can be led to the auxiliary exhaust line. When underway, and the exhaust steam from the auxiliaries in operation is not sufficient to maintain a temperature of 200 degrees with 2 or 3 pounds pressure in auxiliary exhaust, the vapor from the evaporators can be put into the auxiliary exhaust for make-up feed, and its heat will be utilized to raise the temperature of the feed water. By operating the evaporators in this way there is theoretically no loss of heat due to the make-up feed water. In actual practice there is however, a considerable loss of heat due to reducing pressure, leaks, radiation, etc. In order to guard against the danger of drawing over salt water with the vapor it is necessary to have a pressure of several pounds above the atmosphere in the exhaust line, and to throttle down the valves on the evaporator shell so as to wiredraw the vapor.

The chief source of heat for heating the feed water is the auxiliary exhaust steam. The auxiliaries that use an appreciable amount of steam are feed and bilge pumps, air pumps, ash hoists, blowers and ice machine; all simple engines; and the circulating pump engines, which are compound. The reciprocating pumps and the simple engines do not use the steam expansively, and hence a vacuum is not necessary or even important for their proper operation; therefore, raising the back pressure in the auxiliary exhaust line to two or three pounds pressure will affect

the suction of the main feed pumps. A pressure of 10 to 30 pounds is maintained. The main feed pump takes the hot feed water and pumps it to the boilers. The heater is drained by a small drain pipe, discharge from which may be turned into either the main or the auxiliary condenser. There are no traps in this drain line.

The admission of the exhaust steam into the heater is controlled by a stop valve and a spring loaded relief valve, which can be adjusted so that when a certain pressure in the exhaust line is exceeded the valve will lift, and allow a portion of the excess steam to pass into either the main or the auxiliary condenser. At sea, the auxiliary condenser can be shut down and the excess steam and drain led to main condenser.

By keeping 2 or 3 pounds pressure on the auxiliary exhaust, a temperature of 185 to 210 degrees F. is regularly maintained for the feed water. As the power is increased, necessitating more feed water, the steam used by the auxiliaries also increases, and an approximate balance is kept.

In port, the feed heater is used, the discharge from dynamo, air pump and the various drains being the only water discharged direct to the feed tank. The pressure in the exhaust line is, however, lowered, generally to between 0 and 5 inches vacuum. By keeping a slight pressure on the auxiliary exhaust line, air is kept out of the system, a result to be desired.

To maintain continually the high temperature of feed necessitates careful watching to see that heaters are properly drained, that pressure in auxiliary exhaust is kept at desired point, that the spring loaded valves are properly adjusted, and that they work.

REDUCTION OF AVOIDABLE LOSSES FROM LEAKS.

The principal losses are due to steam leaks of various kinds. Leaks in the steam piping are overcome only by exercising the greatest possible care to keep every joint constantly tight. This means constant care, oversight and labor, but the increased economy and efficiency more than repay the extra care and trouble.

A very perceptible loss may be the leakage past steam valves leading to and from steam traps and various drains. In this particular the advantage of having a thoroughly reliable steam trap is brought to light. The steam traps on the *Maryland* are of the Kielly and Mueller type. Usually, when traps do not work properly, their by-pass valves are opened; then, of course, the steam blows directly through to condenser or feed tank. This, of course, is a very considerable loss, especially on a large vessel, where traps and drains are very numerous. In order to have traps in proper working order they must be frequently overhauled.

REDUCTION IN STEAM CONSUMPTION OF AUXILIARIES.

Feed Pumps.—Economy is gained by running fewer pumps at nearly full capacity, rather than a greater number at low speed.

Circulating Pump.—This is one of the largest auxiliaries in use, and by paying proper attention to the necessities of its use a very perceptible gain may be made. It is a common practice, at low powers, to run the circulating pump very much faster than is necessary to supply the required circulating water. If a vacuum of 28 inches is aimed at, it is never necessary to have the discharge water below 95 degrees, and when the temperature of the discharge water is below this the circulating pump should be slowed.

The slowing of the pump in this case has the double effect of requiring less steam for its own operation, and also of causing the water in the feed tank to be warmer; at the same time the maximum vacuum is obtained in the main condenser.

Dynamos.—In a modern ship of war the dynamos use a large percentage of the steam used for auxiliaries. To reduce this consumption, all unnecessary lights and electric auxiliaries should be shut off whenever possible. The dynamo condenser should be run to secure the highest vacuum that can be maintained. The dynamo plant on the *Maryland*, in conformity with the latest practice on large vessels, has a condensing plant of its own. This consists of a Wheeler condenser, with combined air and circulating pumps located in the dynamo room.

SUMMARY.

The principal causes that have tended to produce economy on the *Maryland* are as follows:

1. Care in firing, keeping fires thin and avoiding smoke.
2. Care in keeping boilers thoroughly clean, both inside and out.
3. Use of steam jackets.
4. Using steam at as great a range of expansion as possible by keeping high-pressure cutoff run in as long as the required power can be developed.
5. Maintenance of good vacuum; 27 inches is usually maintained.
6. Maintenance of hot feed water, generally at or above 200 degrees Fahrenheit.
7. Exceedingly great care to avoid steam and water leaks of all descriptions; at stuffing boxes, joints, etc.
8. Operation of evaporators in double effect, and on auxiliary exhaust when under way.
9. Special care to reduce internal friction of all steam cylinders by frequent overhauling, wiping out cylinders and coating them with graphite or graphite grease.
10. Care in shutting down all unnecessary auxiliaries when they are not required.

In general, it may be said that by paying special attention to every little item of loss or possible gain, no matter how small and how indirect, a great saving is obtained. At the same time the conditions that tend to saving in coal produce increased working efficiency and freedom from repairs.

The consumption of coal on the *Maryland* has at sea, been 10 to 20 percent less than that of her sister ships. The saving in money thereby is very considerable, but the saving in general efficiency is much greater. The steaming radius is correspondingly increased, while the work of coaling ship and handling the coal in the bunkers and fire rooms is decreased.

SIDE LAUNCHING OF SMALL STEAMERS.

At the boat yard of Louis Henley, Phœnix, N. Y., some difficulty in launching is experienced, because of shallow water opposite the yard, and, as the boats have to be launched across a tow path, preventing the laying of permanent ground ways for end-launching, it has been found necessary to adopt side launching for the canal boats and steamboats built in the yard.

JUST BEFORE LAUNCHING, SHOWING HANGING WAYS.

These two classes of boats are launched in different ways, the first method being that for canal boats, which are entirely flat bottom. These boats are set up 16 or 18 feet from the edge of the tow path, and three beech ways, about 50 feet long, made each from a tree flattened on two opposite sides, are placed

THE VESSEL STRIKING THE WATER.

under the boat, after having been well tallowed. Shoes are made of beech plank laid across the ways beneath the boat, one being placed on each side of the bottom of the vessel. When constructing the boats, they are set up level, without any grade, and the ways are wedged up tight to the boat, hanging out from the center line over the water unsupported.

From the center line blocking to the edge of the bank under each way are placed blockings provided with such a grade as to give the necessary declivity for launching the boat. Under the center of the side of the hull next the water is set a stout shore, which is afterwards used as a trip, and is driven out by a ram when the boat is to be launched. When everything is ready for placing the boat in the water, the lower blockings are removed by placing the boat upon jack screws, thus leaving the weight of the ways hanging on the trip. When the latter is driven out, the ways tip the boat to the proper grade, and the launching becomes an accomplished fact. There is a perpendicular drop at the edge of the tow path, amounting to from 3 to 6 feet, depending upon the stage of the water in the river, but no difficulty has been experienced on this score.

THE RIGHTMYER AFLOAT AFTER SIDE LAUNCHING.

The other method is used for steamboats, and consists in laying three ways to the proper grade while leaving the boat level. A long shoe, with guides, is bolted on at the upper end to the center way, and the space between the boat and the shoe is blocked up solid. At the time of the launching all blocks are removed, leaving the boat resting upon the shoes, but held from starting by the bolts through the center shoe. When this plank is sawed off below the bolts, the boat is started upon the ways.

Our illustrations show the launching of the canal freight packet *Rightmyer,* which measures 96 feet by 17 feet.

The World's Shipping.

Editor International Marine Engineering:

In taking up the tables of the shipping of the world presented in Lloyd's Register for 1906, the writer noticed with considerable surprise that with the single exception of Japan, the shipping of the United States had made a greater progress in *percentage* during the year than had that of any other nation listed. The figures for percentage are based upon those given in the accompanying table under the heading of "Equivalent Steam," an explanation of which term is in order.

It has been generally considered that the mercantile or commercial value of a sailing vessel of a given tonnage is considerably less than that of a steamer of equivalent tonnage. Various authorities have given different figures for the ratio, but one which is quite commonly adopted is 1 to 4. On this basis the equivalent steam tonnage given in the table is formed by adding to the steam tonnage of each nation one-fourth of the sail tonnage. Of course, the result is considerably less than the total tonnage of the nation in question, but it is a somewhat more reliable index to the total commercial value of the mercantile marine.

It will be noted that the entire tonnage of the world has increased 5.48 percent. British tonnage has not kept up with the average, while American, German, Russian, Swedish, Danish and Japanese are considerably above the average in percentage of increase. The French is almost stationary, showing a very slight decrease, while the Spanish decreased 1.27 percent. The other nations all show increases not far different from the average for the entire world. It will be noted that the tonnage of the United States, above-mentioned, does not include the Great Lakes, but that it is very largely made up of coastwise tonnage.

While it is utterly out of the question to suppose for a moment that the percentages of increase from 1905 to 1906 can be expected to be maintained for any considerable period of time, yet it is interesting to know that if these percentages *were* continued, the American merchant marine would pass in tonnage that of Germany in the year 1925, each nation at that time having,

1905				Nation	1906				Increase percent
Steam	Sail	Total	Equivalent Steam		Steam	Sail	Total	Equivalent Steam	
15,409,538	1,600,182	17,009,720	15,809,584	Great Britain	16,166,748	1,444,348	17,611,096	16,527,835	4.54
3,093,702	471,096	3,564,798	3,211,476	Germany	3,375,743	434,610	3,810,353	3,484,396	8.5
2,558,694	1,437,785	3,996,479	2,918,140	United States	2,827,756	1,413,833	4,241,589	3,181,214	9.03
1,260,973	467,065	1,728,038	1,377,739	France	1,253,737	487,458	1,741,195	1,375,602	— 0.15
1,081,335	694,883	1,776,218	1,255,056	Norway	1,145,545	692,334	1,837,879	1,318,629	5.06
870,839	2,713	873,552	871,517	Japan	996,553	3,540	1,000,093	997,438	14.45
741,110	447,956	1,189,066	853,099	Italy	775,069	429,359	1,204,428	882,409	3.44
639,062	223,847	862,909	695,024	Russia	694,063	219,070	913,133	748,831	7.75
592,695	211,651	804,346	645,608	Sweden	650,768	205,930	856,698	702,251	8.78
693,265	38,316	731,581	702,844	Spain	684,339	38,173	722,512	693,882	— 1.27
659,409	42,345	701,754	669,995	Holland	683,180	36,115	719,295	692,209	3.32
604,669	13,525	618,194	608,050	Austria	618,031	12,446	630,477	621,143	2.15
537,242	89,270	626,512	559,560	Denmark	579,464	80,837	660,301	599,673	7.17
1,220,859	296,867	1,517,726	1,295,076	All Others	1,293,908	311,060	1,604,968	1,371,670	5.91
29,963,392	6,037,501	36,000,893	31,472,768	Total	31,744,904	5,809,113	37,554,017	33,197,182	5.48

according to this calculation, a tonnage about equivalent to that now possessed by Great Britain and her colonies. At that time the British tonnage would be considerably more than double what it now is, while the Japanese, with the large percentage of increase shown during the last year, would not be very far behind the German and American. Such computations are, of course, mere idle speculation, and really involve nothing more than a calculation based upon compound interest.

It will be noted that there are no less than thirteen nations, each of which has a tonnage of more than five hundred thousand, but that only five of these nations have as much as one million tons, the remaining eight being pretty closely grouped, and exhibiting from year to year fluctuations in relative position in the column. Thus it will be noted that during the year, both Russia and Sweden have passed Spain, and Sweden has also passed Holland. Another feature of the table which may cause a little surprise is that Spain, in spite of a decrease during the year, still has a larger tonnage than has Holland. Another surprise is in the very creditable growth in Russian tonnage.

The total steam and sail tonnage included is 37,554,017, as against 36,000,893 in 1905, and 34,789,189 in 1904. It will be noted that the steam tonnage has increased during the year from 29,963,392 to 31,744,904, or 6 percent. During the same period, sail tonnage has decreased from 6,037,501 to 5,809,113, or 3.79 percent. At the present rate of change, it will not be long before the sail tonnage will have become almost insignificant in comparison with that propelled by steam. It is only within a year or two, however, that the *number* of steam vessels included in the tables has reached and passed the figure represented by the number of sailing vessels so included. N. S. Yendis.

THE JERSEY CITY REPAIR YARD OF THE JAMES REILLY COMPANY.

A New York Harbor Repair Yard.

The James Reilly Repair & Supply Company has recently been making some extensive improvements, both at its manufacturing and repair plant in Jersey City, and in its supply department at 229-230 West street, New York.

The Jersey City plant has been entirely rebuilt, and equipped with all modern tools and appliances for marine work, as well as for manufacturing engineering specialties. The company has built in front of its works a mooring pier six hundred feet long, where vessels can have a comfortable berth while undergoing repairs. The location of this plant is one of the most convenient in the harbor of New York, being immediately next to the Pennsylvania Railroad ferries, running to Twenty-third street, Desbrosses street, Cortlandt street, and the Brooklyn annex. There are two P. R. R. switches in the place, one at Grand street and one at Sussex street, making it convenient to load and unload machinery and supplies. A small industrial track runs all around the building, to facilitate the handling of heavy material. Duplicate air compressors are installed, and air and water pipes conducted down to the end of the mooring pier. Since the remodeling of this plant the shops have been very busy.

The new supply building on West street is one of the most modern structures of the kind in the city of New York. It has been especially built and equipped for the purpose of conducting a ship chandlery, hardware, and contractors' supply business. The building is six story, 50 by 110 feet inside, has two electric elevators, and contains, besides the supply department, the general offices of the company.

In 1892 the company was incorporated, and took over the operation of the repair shops formerly conducted by the International Navigation Company (American and Red Star Lines) at Jersey City.

The business has steadily grown from a very small beginning to one of great proportions, and is peculiar in itself, inasmuch as it embraces everything required for a ship. It might truly be called a marine department store, where the ship owner can have his vessel dry docked, repaired, and completely stored with everything required for a long voyage.

MOTOR BOATS.

PART XVI.

BY DR. WILLIAM F. DURAND.

TROUBLES, AND HOW TO LOOK FOR THEM.

The number of ways in which a gasoline engine may fail to operate properly, and the number of causes which may contribute to trouble, are legion, and within present limitations only some general principles can be given as an aid in locating trouble when it arises. The location of trouble in the operation of a gasoline engine is exactly a process of diagnosis, and this again is a process of analysis and isolation. The operation, as a whole, must be resolved into its various parts or functions, and one item after another of the mechanism and equipment must be examined, in order to gradually isolate, and thus by a process of exhaustion ultimately locate, the seat of the trouble.

The operation of a gasoline engine, aside from the mechanism itself, demands the simultaneous realization of two chief functions or conditions:

(1) An electric spark of sufficient intensity to ignite a proper mixture of gasoline vapor and air compressed to a point suitable for such ignition, and occurring at or near the end of the compression stroke.

(2) The provision of a charge of gasoline vapor mixed with a suitable proportion of air and compressed at the end of the stroke to a pressure suitable for ignition.

These two main conditions, one referring to the electrical spark and the other to the charge of gasoline, are, of course,

quite independent, and may be taken up each in turn, and in either order, until the trouble is located.

In the absence of specific indications, as referred to later, the point of most direct attack is usually the existence or non-existence of a spark. This can generally be ascertained by such observations as will readily present themselves to mind. If a full and adequate spark is formed, then attention must next be given to the question as to whether it is formed at the right point in the stroke. It is perfectly possible for a commutator to become disturbed in adjustment, or for other derangement to displace the instant of forming the spark relative to the piston position, to such an extent as to render it of no avail for the ignition of the charge. In short, here, as at all other points, care must be taken to insure the complete fulfilment of all items of the electrical condition—not alone the existence of a vigorous spark, but one so located as to come at or near the end of the compression stroke, and thus available for the ignition of the charge. If no spark whatever is formed, or if it is feeble or uncertain, then there is trouble somewhere on the electrical side, and the problem becomes one of further localisation.

We must remember that electrical energy operates in closed circuits, and that a break or disturbance at any point in such a circuit may prevent its performing its proper function. In the wipe contact system of ignition there is one such circuit, in the jump spark, two. In a search of this character we may either start from the batteries as the fountain head, and follow down to the ignition plug or wiper terminals, or we may proceed in the inverse direction. Usually the former is the more satisfactory and definite in results. Thus, place a voltmeter or ammeter across the terminals of the battery, or in the absence of such instruments, watch for a spark when shortcircuited and broken by a bit of wire, or better still by a small magnet coil. The spark, or its absence, will show whether the battery is in good condition. If not, a broken or poor contact may be found at some of the terminals or connections between the cells. It may even be necessary to test out each cell separately, thus giving definite assurance in the end that the battery is or is not at fault.

If the battery is all right, and the wipe spark is used, then the instrument or short circuiting coil applied along at one or two intermediate points will serve to bring the problem down to the engine, and if the search has been properly carried out, the trouble will surely be found by the time we reach the wiper terminals in the cylinder. In general, electrical trouble must be looked for at junctions and connections, and at the terminals in the cylinder. The conditions for good electrical conductivity are simple—continuous connection and good firm contact between bright metallic surfaces; and search should be especially directed to see if these conditions are fulfilled.

If the jump spark system is used, the same principles apply, but we may find troubles differing in detail Thus, the vibrator or make and break of the primary circuit may be out of order, and thus fail to operate with its accustomed buzz. If the primary current itself is all right, then trouble at the vibrator is of a mechanical nature, and is usually a matter of adjustment of the armature and controlling springs. Cases have been known where, with a relatively weak spring, the rate of vibration of the armature was too slow for the higher speeds of the engine, while quite sufficient for low speeds. In consequence, the engine would operate quite satisfactorily at low speeds, but would begin to miss fire and operate irregularly at the higher speeds. A stiffer spring with proper adjustment and suitable battery power is the remedy indicated.

Again, within the cylinder, the sparking points may become separated too far, or incrusted with non-conducting substance to such degree as to impede or interrupt the passage of the secondary spark. In any and all cases the same general principles apply. It is simply a matter of careful search at one point after another, conducted in an orderly manner, and in such routine as to gradually eliminate one possibility after another, until finally, by, a process of exclusion, the difficulty must be located.

If the first direct test at the terminals of the electrical circuit indicates no trouble of an electrical character, then the location of the trouble must be sought in the other general condition, that relating to the explosive charge. Here the general conditions to be fulfilled may be classified under perhaps four headings, as follows:

(1) The supply of gasoline must be ample, but not in excess.

(2) It must be vaporized, and mixed with a proper proportion of air.

(3) It must be compressed to a pressure suitable for ignition.

(4) Waste gases or foreign substances, such as cylinder oil, carbon deposit, etc., must not be present, beyond a safe small amount.

In the search for trouble, all of these conditions must be borne in mind, and by the same general policy of exclusion the trouble must ultimately be located. Trouble with the supply of gasoline may arise in a variety of ways. The supply in the tank may be exhausted; the air relief valve or opening may be closed; some valve or turn or pipe may be clogged with sediment or foreign matter; some connection or pipe may be broken, and the supply thus interrupted by leakage; the carbureter may be out of order by clogging or by lack of adjustment; the opening of the gasoline throttle may be too great or too little, either flooding the cylinder with an excess or furnishing an inadequate supply.

Again, trouble in vaporization or with the proportion of air may be due to faulty construction of the carbureter or to faulty adjustment, especially with reference to the air supply.

Failure to secure proper compression may be due to a leaky piston, or, in the case of a four-cycle engine, to leaky valves, either supply or exhaust, allowing the compressed vapor to escape instead of retaining it in the cylinder to the proper point of compression.

The quality of the charge may be injuriously affected by the presence of waste gases in too great proportion, or by cylinder oil or carbon in undue amount. The presence of these latter may be prejudicial, not primarily because of their effect on the explosive character of the charge itself, but rather, as previously noted, because they are liable to clog the sparking points, and require an electrical pressure greater than the battery can afford in order to make an effective spark.

Troubles of a mechanical character may also arise in great number, but to these we shall give no present attention beyond the general caution that all bearings, pin joints and connections must be carefully watched for wear, proper lubrication must be insured, and in particular the condition of the piston and inner surfaces of the cylinder must be safeguarded by sufficient but not by an excess of cylinder oil, and by an adequate and continuous supply of cooling water.

SYMPTOMS OF TROUBLE.

As with diseases in the human body, the same symptom may often be due to widely different causes. Still, an intelligent and critical examination of the symptoms will often give valuable indications regarding the cause of the trouble, and in any event, before any general hunt for the location of trouble, a careful study of the symptoms should be made. Some of the more common symptoms are noted below, with the possible indications to which they may refer.

(1) *The explosions cease suddenly* and without warning, bringing the engine from full power to a sudden stop. The trouble here is probably electrical, and the symptoms imply a sudden break in the electrical circuit or derangement in the electrical apparatus, cutting off the spark suddenly and completely

(2) *The explosions miss occasionally* and with varying frequency. This condition may be due to a variety of causes. The

battery may be losing its strength, or there may be a vibrating contact. By the latter is meant a point where the copper of a wire is broken, but the ends are so held by the insulation, or otherwise, as to remain nearly in contact, and by the vibration due to running they may be occasionally brought into contact and thus allow the spark to form; or if normally in contact the vibration may occasionally separate the ends, in either case producing an irregular operation in accordance with the formation of the spark.

The same symptoms may also be due to fouling of the spark points, to fouling of the commutator with oil or foreign matter, to trouble with the vibrator, to improper quality of the explosive charge, to insufficient compression, or, in fact, to a derangement in almost any one of the many conditions which must be simultaneously fulfilled, and in such manner as to permit an uninterrupted fulfilment of such conditions.

(3) *Weak explosions.*—This symptom may be due to improper quality of the explosive charge due to derangement of the carbureter, or to any other derangement which may interfere with the quality of the charge; also to insufficient compression, and consequently incomplete or retarded combustion; also to the formation of the spark at the wrong point in the piston stroke. The size and character of the spark have also some influence on the strength of the explosion. This, as well as the preceding symptom, may thus be due to a wide range of causes.

(4) *The engine slows down or stops,* and examination shows that the cylinder is excessively hot, and that the piston moves very stiffly in the cylinder. These general symptoms indicate insufficient lubrication or cooling or both, and the sticking of the piston within the cylinder.

(5) *The explosions gradually become weaker* and the engine finally comes to rest. This result may be due to any continuous and perhaps rapid development of conditions which may serve to disturb the operation of the machine, and perhaps bring it to a standstill. The supply of gasoline may first be examined, and if adequate the most probable location of the trouble will be in the electrical circuit somewhere, and presumably in the batteries.

(6) *Muffler Explosions.*—An explosion in the muffler is due to the passage of unburned gas from the cylinder through the exhaust into the muffler. This usually implies faulty ignition, in which case an entire charge may pass into the muffler and become ignited by the hot gases from the following exhaust stroke, or by a bit of glowing carbon or otherwise. The cause of the faulty ignition may, of course, be traceable either to the quality of the charge or to the spark, or both, and the search for final causes must be sufficiently comprehensive to cover all possibilities bearing on these conditions.

(7) *Crank Case Explosions.*—These occur only in a two-cycle engine, and are due either to delayed ignition, or to a weak and slow burning mixture. In such case there is a possibility of the passage of flame from the cylinder into the crank case along the line of the entering fresh charge. The obvious remedy is to advance the spark, or to attend to the quality of the mixture.

The more common derangements may also be mentioned, together with a statement of the usual immediate consequences.

(1) *Ignition very late.*—Difficulty in getting explosions, and if obtained, the power developed is small and operation irregular. Liability to crank case explosions with two-cycle engines. The condition may also contribute to cause muffler explosions.

(2) *Ignition very early.*—Difficulty in getting explosions, or if obtained, the piston is momentarily retarded, excessive stresses are thrown on the working parts, and the operation of the engine is irregular and jerky.

(3) *Vibrator spring too weak.*—Engine will operate properly at moderate speeds, but ignition will become irregular as the speed is increased.

(4) *Poor electricol contact or break at any point in circuit.*—Uncertain spark or no spark and corresponding explosions.

(5) *Stoppage in gasoline pipe or connections.*—Engine slows down and stops.

(6) *Carburcter improperly adjusted.*—Quality of mixture bad, and engine will operate irregularly or not at all, or well at some speeds and poorly at others.

(7) *Exhaust valve not tight or spring too weak.*—Inflow of air with explosive charge, and disturbance in quality of mixture. Likewise, escape of mixture under compression and difficulty in obtaining proper pressure for ignition.

(8) *Inlet valve not tight.*—Escape of mixture under compression, and difficulty in obtaining proper pressure for ignition.

(9) *Piston leaky.*—Same general result as for leaky valves.

(10) *Excess of gasoline.*—Quality of mixture too rich. Difficulty in ignition or in starting engine. Smoke may show in exhaust—usually black in color.

(11) *Excess of lubricating oil.*—Spark points become fouled by solid carbon or viscid mixture, with uncertain or difficult ignition. Smoke shows in exhaust—usually light gray in color. Presence of carbon may cause preignition, kicking, or back firing into crank case or carbureter.

With reference to the entire problem of trouble hunting, it should be understood that the ability to quickly locate and to properly treat such troubles as are liable to arise in the operation of a gasoline engine cannot be acquired by any mere study of symptoms and causes or derangements and results. The study must be fundamental rather than symptomatic, and must have for its purpose the thorough understanding of the conditions of operation of a gasoline engine, and the development of an analytical habit of mind with reference to the logical connection between such symptoms as may appear, and the conditions of operation. With such habit of mind and a careful examination by the method of exclusion, the trouble may be surely and definitely located, and the remedy applied.

Progress of Naval Vessels.

The Bureau of Construction and Repair, Navy Department, reports under date of August 11, 1906, the following percentage of completion of vessels building for the United States Navy:

			July 1	Aug. 1
BATTLESHIPS.				
Nebraska	19 knots.	Moran Brothers Co.	95.16	96.
Georgia	19 "	Bath Iron Works	97.47	98.43
Connecticut	18 "	Navy Yard, New York, N. Y.	97.41	97.6
Vermont	18 "	Fore River Shipbuilding Co.	88.5	90.5
Kansas	18 "	New York Shipbuilding Co.	85.2	85.8
Minnesota	18 "	Newport News Co.	91.44	93.68
Mississippi	17 "	Wm. Cramp & Sons	59.86	60.83
Idaho	17 "	Wm. Cramp & Sons	58.07	59.
New Hampshire	18 "	New York Shipbuilding Co.	48.	50.3
ARMORED CRUISERS.				
California	22 knots.	Union Iron Works	94.	94.6
South Dakota	22 "	Union Iron Works	91.8	92.4
North Carolina	22 "	Newport News Co.	50.5	53.87
Montana	22 "	Newport News Co.	44.72	47.66
SEMI-ARMORED CRUISERS.				
St. Louis	22 knots.	Neafie & Levy Co.	98.77	99.22
Milwaukee	22 "	Union Iron Works	96.1	97.9
SCOUT CRUISERS.				
Chester	24 knots.	Bath Iron Works	36.88	40.8
Birmingham	24 "	Fore River Shipbuilding Co.	38.4	41.8
Salem	24 "	Fore River Shipbuilding Co.	39 3	42.6
SUBMARINE TORPEDO BOATS.				
Cuttlefish		Fore River Shipbuilding Co.	75 9	81.7
Viper		Fore River Shipbuilding Co.	62.	69 3
Tarantula		Fore River Shipbuilding Co.	72.3	81.3
Octopus		Fore River Shipbuilding Co.	59	65.1

OBITUARY.

James Dredge, managing editor of *Engineering* (London), died August 16. Mr. Dredge was born in Bath, England, in 1840, and long occupied a position of great prominence in the engineering field, and particularly along the line of technical journalism. He was author of a number of books, and was repeatedly honored by royal commissions and decorations of various sorts.

THE NEW FLOATING COAL DEPOT IN PORTSMOUTH HARBOR.

BY FRANK C. PERKINS.

A most interesting floating coal depot has recently been designed and constructed for the British Admiralty, for storing great quantities of coal afloat under the most favorable conditions, placing the same in bags very rapidly by means of the latest labor saving devices, and without hand shoveling, to be discharged later to war vessels by modern transporting devices. The photograph shows the floating depot at her moorings in Portsmouth harbor, taking in coal from a 6,000-ton collier. The drawings show the method of working the Temperly transporters employed in the work of transferring the coal to and from the depot.

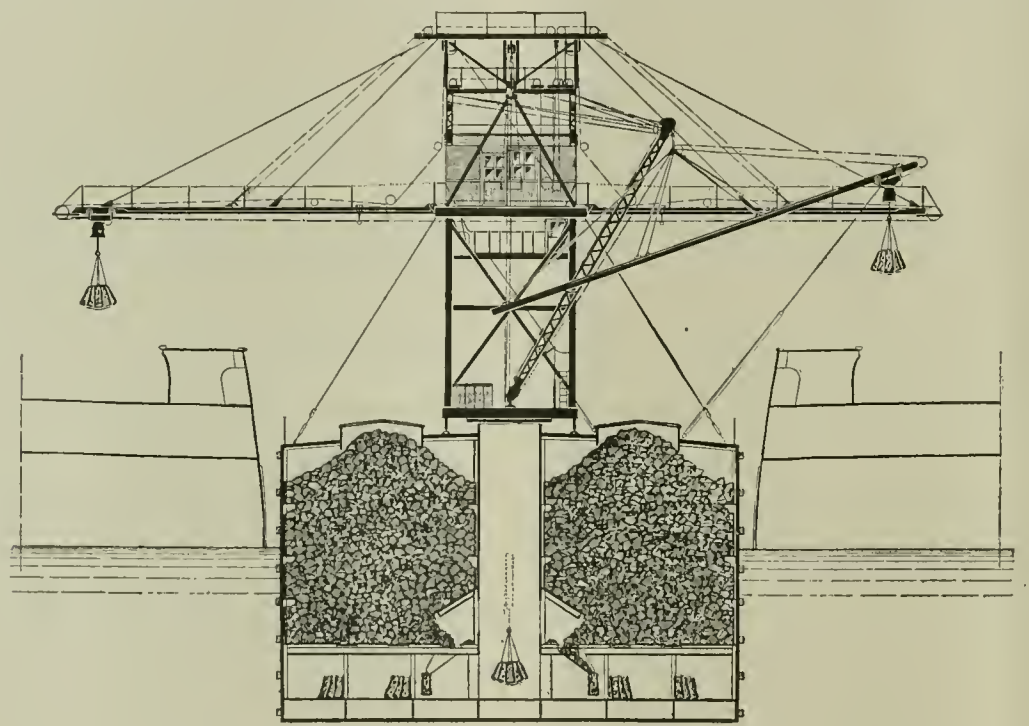
It is maintained that the advantages secured by the use of the floating depot are many, no valuable dock space being occupied, there being great storage capacity, and no breakage of coal in unloading, while the fuel is stored under cover. The mobility of the depot is also considered of great importance. The bags or skips are filled and assembled on smooth floors, while 10,000 bags may be kept filled below the hoppers, ready for immediate delivery at the exceptionally high rate of 700 tons per hour. There is also the advantage that two or more vessels can coal at once, and the fuel may be transported direct from the collier to the war vessel, while the men at work are sheltered from the weather, with perfect ventilation and freedom from danger.

It is claimed that the apparently insuperable difficulty hitherto experienced of getting Welsh steam coal to run or flow through openings in the bottom or sides of hoppers, owing to the large lumps of coal bridging over and blocking the opening when under pressure, is entirely and satisfactorily solved by this system. The result is obtained by the provision of suitable baffles so arranged in the coal spaces as to relieve the pressure from one row or several rows of openings, and at the same time afford safe shelter for a man to approach the openings and help the flow when any unusually large pieces get in the way.

As will be noted by the illustration and drawings, the hull of the depot is in the form of a large flat-bottomed, straight-sided vessel with bluff ends, and is of strong and simple construction throughout. It is subdivided by six transverse watertight bulkheads into seven compartments. There are five middle compartments which contain the ten coal hoppers, the after-end compartment containing the electric generating machinery, and the forward-end compartment being appropriated for crew accommodation and stores.

There are two longitudinal bulkheads in the middle of the vessel, which divide the five holds into ten hoppers, and afford a clear passageway between them, giving access through numerous openings to the spaces under the hoppers, and providing a clear exit up through which the bags of coal are hoisted by the transporters at any point in the length of the depot.

It will be noted that the bottom of the coal hoppers is raised above the floors of the vessel, and provided with trap-doors and movable chutes of special design for tapping the coal from below and regulating its flow into bags without shoveling. The chutes being entirely underneath the hoppers, the men operating them are safely protected from any coal dropping from the load.



SECTION OF FLOATING COAL DEPOT, SHOWING METHOD OF OPERATION.

Inside the hoppers, and next the longitudinal bulkheads, a sloping baffle deck projects over the nearest row of trap-doors, relieving these trap-doors from the pressure of the superincumbent coal, and allowing men to safely enter the hoppers through openings in the longitudinal bulkhead for the purpose of breaking up such lumps of coal as are too large to go into the bags.

A complete system of exhaust-air tubes is provided, and the coal dust arising at the chutes is drawn off by means of electric fans and delivered back into the receivers in the hoppers, where it may be subsequently bagged or otherwise dealt with. The suction of these exhaust tubes necessarily induces a downward current of fresh air, and so supplies the required ventilation.

There are three rows of very long hatchways provided throughout the length of the holds, the central row being over the central passage, for the discharge of the coal in bags, and the side rows over the hoppers for loading coal into the depot.

As seen in the views, the vessel is loaded and discharged by means of twelve transporters worked by electricity. The transporters are carried on four traveling towers, which run on a railway laid on the deck of the depot throughout its length. Three transporters are carried by each tower. Two of these

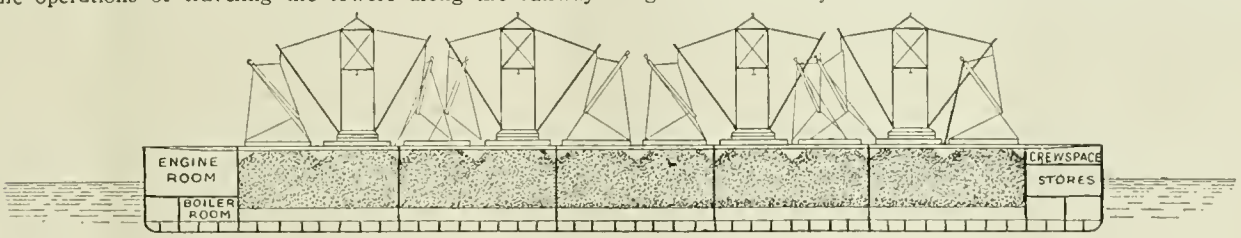
are inclined portable transporters of the latest standard pattern, and may be used for loading the depot from a collier, or for coaling a war vessel from the depot; the other transporter is horizontal, and long enough to reach from the hatchway of a collier on one side of the depot to the deck of a war vessel on the other. It may, therefore, be used not only in the same way as the other two, but also for transferring coal from a collier direct to the war vessel.

All the operations of traveling the towers along the railway on deck, raising and lowering the overhanging arms of the beams, raising and lowering the derricks with their portable transporters, hoisting and transporting the coal, etc., are performed by electric winches which are on raised platforms, from which the operators have a commanding view of the operations. Furthermore the four towers can be quickly moved by electric power to any required positions on the deck of the depot, and the twelve transporters can be easily trained either all over one side of the depot, or divided in any proportion and in any order between the two sides. The portable transporters being capable of being slewed through a considerable distance relatively to the towers it is practicable to so arrange all the transporters as to command every point along the deck of the vessel or vessels being coaled. This arrangement of the transporters gives the greatest possible range of action.

Automatic dumping skips are employed for loading the depot. These are lowered full of coal to within a foot or two of the coal already in the hold, but without resting on it, and are there automatically upset, so as to gently empty the coal on to the heap. When not in use the overhanging arms of the horizontal transporters are hinged up out of the way, the lifting and lowering being rapidly effected by electric gear. The portable transporters when not in use are slewed inboard. Under the hoppers the space is used for storing coal in bags, of which about 1,000 tons can be accommodated, thus providing a good supply for immediate and rapid transshipment. This storage space is utilized for filling bags in advance of requirements.

All of the electric power for working the twelve transporters, ten exhaust fans, and two electric windlasses, and for lighting the depot, is derived from three generators, having an aggregate output of about 600 horsepower, driven by steam, and placed in the after compartment of the vessel. Steam is supplied to the engines by two cylindrical return tube boilers.

THE COAL DEPOT LOADING COAL FROM A COLLIER ALONGSIDE.



LONGITUDINAL SECTION OF THE FLOATING COAL DEPOT.

Merchant Marine League Prizes.

The upbuilding of the shipping of the United States in the foreign trade is a subject which forms the *raison d'etre* of the Merchant Marine League of the United States, the headquarters of which are in Cleveland, Ohio. The fact that our shipping in foreign trade is less to-day in tonnage than it was in 1810, in spite of the stupendous increase in the aggregate amount of that trade, and the fact that it is only about one-third as great as it was at the outbreak of the civil war in 1861, have accounted for the organization of the League; and a campaign is being carried on looking to the institution of such measures as will result in placing this particular phase of our national life upon a basis commensurate with its importance.

Prizes aggregating $1,000 are offered by the League for the four best essays on "How to Build Up Our Shipping in the Foreign Trade," only students in high schools, technological schools, colleges, and universities in the United States being eligible to compete. There will be four prizes, viz: one of $400, one of $300, one of $200, and one of $100. Students desiring to compete for these prizes must register their names, and the institutions of learning which they are attending, with the League, in order to have their essays considered. Essays must not exceed 2,500 words; they must be typewritten, on one side of the paper only. The author's name must not be signed to his essay—only his nom de plume—which latter, with his full name and address, must accompany the essay in a separate sealed envelope. No limitation is set upon the method or plan that may be advocated; it may be along the line of protection or free trade. The contests will close about November 15, and the prizes will be awarded about December 15, 1906.

INTERNATIONAL MARINE ENGINEERING

Published Monthly at
17 Battery Place - - NEW YORK
By MARINE ENGINEERING, INCORPORATED
Christopher St., Finsbury Square, London, E. C.

TERMS OF SUBSCRIPTION

	Per Year	Per Copy
United States, Canada and Mexico	$2.00	20 cents
Great Britain and Ireland	10/6	1/
Other countries in the Postal Union	10/6	1/

Entered at New York Post Office as second-class matter.
Copyright, 1906, by Marine Engineering, Inc., New York.
INTERNATIONAL MARINE ENGINEERING is registered in the United States Patent Office.
Copyright in Great Britain; entered at Stationers' Hall, London.

Notice to Advertisers.

Changes to be made in copy, or in orders for advertisements, must be in our hands not later than the 5th of the month, to insure the carrying out of such instructions in the issue of the month following. If proof is to be submitted, copy must be in our hands not later than the 1st of the month.

The edition of this issue comprises 6,000 copies. We have no free list, accept no return copies and issue only enough to supply the regular demond.

The New London Address.

Our London office has just been moved into much more spacious and commodious quarters in a new building on Christopher street, Finsbury Square, London, E. C. It is hoped that the new quarters will prove ample for our use for some time to come.

Engine Design.

It frequently happens in marine engineering work that a design is required of an engine to fulfil certain specific conditions, and under circumstances when time does not permit the development of a design from its inception, and the making of the necessary drawings. An engine of general utility, and of about 100 horsepower, thoroughly fitted for use in small boats using screw propellers, is presented this month with very considerable detail in the way of drawings. This engine has been thoroughly tested in practical work, as is evidenced by the report of the test, incorporated in the article, and has shown itself thoroughly well capable of performing the duty for which it was intended. While of course this particular design covers simply a single size and power, yet it is of sufficiently standardized character to be readily transformable into an engine of considerably greater or smaller size by relatively simple alteration of dimensions. The engine was designed for steady and somewhat heavy work in connection with boats in New York harbor, and would seem to amply fulfil all requirements in this respect.

This subject of standardization of engine details is one which has received considerable attention of late at the hands of the British Admiralty, and also among the merchant ship and engine builders of Great Britain. It is a matter of extreme importance, partly on the score of ready repairs and interchangeability of parts, and partly (on the manufacturing side) on the score of low expense for patterns and drawings, these covering often a considerable number of engines of the same power. Of course, as designs progress, alterations and changes are frequently made which improve the operation of each engine over that of those preceding, but in general the improvement is relatively slight in extent, and it is frequently doubtful if it is nearly as important as the matter of interchangeability of parts as between engines, and the possibility of making rapid repairs in case such should prove necessary.

An Epidemic of Shipwrecks.

There has been forcibly brought to our attention during the past few weeks the great liability of modern ships, however well built and operated, to disaster at sea, or, more particularly, in the neighborhood of the coast line; and in many cases to complete loss, in spite of all that could be done in the way of prevention, and of salvage operations after prevention became an impossibility.

The British battleship *Montagu* was lost early in the summer through running hard aground on Lundy Island in a fog, and being placed in such a position that in spite of the utmost endeavors nothing could be done to save the vessel, and but little in the way of saving her armament and equipment. Shortly after this, the American battleship *Alabama* went aground in Newport harbor, and the *Rhode Island* in Chesapeake Bay, but both were fortunately hauled off with little damage. A little later the American cruiser *Boston* went ashore near the entrance of Puget Sound, and was for a time supposed to be irrecoverable. The efforts put forward, however, were successful, and, although the ship had a bad leak, she was successfully removed from her position and taken to dry dock.

In the merchant marine, the Pacific Mail steamer *Manchuria* was run aground on one of the Hawaiian Islands and the *Mongolia* on Midway Island. A few days later the United States transport *Sheridan* ran ashore not far from the place where the *Manchuria* met her fate, and became a total loss.

In some of these cases investigations into the accidents have been made, and certain officers reprimanded for not taking the very best of care of their commands. As a general proposition, however, the mishaps to these various ships have come, not so much through negligence as through the operation of

fogs, or other natural phenomena which are extremely common at sea, and which cannot be prevented by any means at present open to mankind. It goes without saying that under such circumstances vigilance on ships at sea is redoubled, and when an accident occurs in spite of this increased vigilance, it simply serves to emphasize the utter dependence of sea-faring men on maintenance of such conditions of weather as will permit them to obtain frequent and accurate information as to their exact location upon the expanse of the ocean.

In the cases where these vessels were totally lost no reasonable provision in the way of extra strengthening of the bottoms would have prevented this loss, because of the fact that without introducing absolutely prohibitive weights the bottoms of ships cannot be made sufficiently strong to successfully sustain contact with hard rock formations. The intimate subdivisions of the double bottoms prevented in each case any sudden sinking of the ship after striking the obstacle, and fortunately no loss of life was reported. The number of accidents, however, coming so close together, serves to emphasize the extreme importance of extraordinary precautions under circumstances such as those to which allusion has been made earlier in this comment.

Engineering Information.

Our first article in this number is a very comprehensive description of the new Southern Pacific steamer *Creole,* this being the first steamer of any importance to be fitted with Curtis turbines as a propelling mechanism. The owners and builders of this epoch-making ship have afforded us every facility for obtaining the information, and the result cannot but be beneficial to all concerned. The generous and open-minded spirit which has actuated the officials in question is one that is met all too rarely in connection with manufacturing of most sorts, and in particular in connection with the building of ships.

It is, of course, only natural that a shipbuilder who has devoted years of his life and energy to developing methods of his own for accomplishing a certain result in a certain way, should desire to conserve all information regarding his methods and results to himself, or for the use of his own company, and to the exclusion of all others. At the same time it cannot but be recognized that any competitor desiring to obtain information of this character can not really be balked, if his attempt be made with a determination to accomplish results. Cases have come to our attention where engineers, disguised as laborers, have found it very easy to enter plants from which they had previously been rigidly excluded by the officials in charge, when presenting themselves at the office and desiring to inspect the processes of manufacture or methods of handling materials. As the information, therefore, cannot be kept secret from those most interested in obtaining it, there seems to be no good reason why the shipbuilder should not frankly take the engineering and shipbuilding public into his confidence in at least the broader general lines along which he is working, and give to the world the concrete results of his work, in the form of carefully prepared and well-illustrated descriptions of individual ships of importance.

Much comment has been made upon the extreme reticence observed in most quarters about the steam turbine, in its various forms and designs. Our present article gives a considerable amount of information on this subject, together with splendid photographs illustrating the Curtis turbine at all stages in the manufacture and assembling, and forms a refreshing contrast to the meager divulgences dictated by the almost mulish obstinacy of those usually having in charge the design and construction of such pieces of mechanism. It is beyond all question a fact that had the truth been known some years ago regarding the developments, along the line of which turbine engineers were working, the turbine would be to-day in a much more forward state, both in regard to design and in regard to extent of use. This follows from the fact that other engineering minds would have taken hold of the subject, inventions and innovations would have come more rapidly, and everything in connection with the design and operation would have been advanced very, very far beyond what is at present found to be the case. This advancement might have been of slight direct benefit to those at that time building turbines, but it could not well have been detrimental; and the advantage to the world would have been enormous.

Another phase of this subject is concerned with the accuracy and reliability of such information as finds its way into print. When the material is given by the builder, it is bound to be accurate, and, therefore, there can be little opportunity for misrepresentation in any particular. Where, however, as is too frequently the case, the seeker after information is obliged to use such as he can obtain from any irregular source which may present itself, there is bound to be great inaccuracy and frequent misrepresentation, sometimes in very important particulars. From the point of view, therefore, of being accurately represented in the eyes of the world, and particularly of the technical world, it behooves the manufacturer and shipbuilder to see that such information as is published is correct; and the only apparent way in which this result can be assured is by issuing the information direct to such as are interested in obtaining it.

ABSTRACT FROM RULES AND REGULATIONS OF BUREAU VERITAS.

EDITION OF 1905.

ARRANGED BY HARRISON S. TAFT.

PART VI.

39. General.

1. The three deck type of vessel is to be preferred in the construction of tank vessels.

2. The oil should go to the shell plating of the ship. If double bottoms are fitted, said spaces must be thoroughly ventilated.

3. There must be at least one continuous longitudina bulkhead throughout the oil spaces, deep water ballast tanks and cofferdams, said bulkhead extending to the top of the expansion tanks.

4. There must be a sufficient number of athwartship bulkheads to provide ample stability in filling or emptying the tanks. In steamers they are to be not more than 28 feet apart.

5. Each compartment must have an expansion tank extending above the "crown deck," the capacity of said tank being at least 6 percent that of the compartment to which it is fitted.

6. There must be a cofferdam at each end of the spaces devoted to an oil cargo, extending the entire breadth of the ship, and from the keel up to the highest point of the expansion trunkway. They are to be at least two frame spaces wide, and to be well ventilated.

7. Each oil compartment is to be tested before launching or in dry dock, by a head of water eleven feet above the "crown deck" of the tanks, or four feet above the top of the expansion tank hatch covers.

8. All cofferdams, pump rooms and other spaces must be efficiently ventilated.

9. It is recommended to locate the machinery in oil steamers entirely abaft the oil spaces, with the after cofferdam between the oil and the machinery spaces.

If the machinery is located amidships care must be taken to entirely isolate the shaft tunnel from the engine space with a cofferdam at both the forward and after ends of the machinery space, extending to the upper deck.

10. The galley, also the main and donkey boiler furnaces, are to be absolutely isolated from all contact with the oil cargo. It is advisable to locate the donkey boiler above the level of the main deck. No external door will be allowed to the donkey boiler firing space, unless it is placed on the upper deck abaft the oil tanks.

11. Electric lights to be fitted throughout on the double wire system. In all oil vessels, alternating current dynamos are absolutely prohibited, and single wire plants should not be fitted. The leads must not be run through the tanks, and no switches, cut outs or joints should be placed in the pump rooms.

12. As the safety of oil-carrying vessels depends upon perfect workmanship, especially of the riveted connections, it is advisable, in order to reduce the number of said connections, to use channels, Z-bars or other rolled bars and flanged plates, wherever possible.

13. Where the spaces at sides of expansion trunks are used as spare bunkers, or where any large quantity of coal is carried between decks, the deck in way of same must be coated with an approved composition.

40. Keels and Center Line Keelsons.

1. Plate keels.

(*a*) The flat plate type of keel only should be adopted, the plates being 20 percent heavier than in ordinary vessels. A single plate keel may be used where a double plate keel is called for (see section 5, paragraph 1-*b*) if the thickness of the keel plate is increased by 75 percent.

(*b*) The width of the plates should be 1½ times their width in ordinary vessels, in order to provide a secure fastening of said plates to the frames.

2. Center Line Keelsons.

(*a*) The center line keelson is to form the lower strake of the center line longitudinal bulkhead. It is to be worked continuously all fore and aft, maintaining its midship scantling for the 2/3 length amidships

(*b*) It is to be connected to the flat plate keel by double angle bars worked continuously. Said bars may be cut at an oil-tight bulkhead, but cutting is not recommended, even at a non-oil-tight bulkhead.

(*c*) The depth of said keelson must be such as to bring its lap with the center line longitudinal bulkhead plating above the floor plate brackets to said keelson.

41. Frames.

1. The frames should be cut short from the center line keelson by an amount not exceeding 9 inches, so as to provide a free flow for the oil to the pumps.

2. When the frames are cut at the second deck in two or more decked vessels so as to form an oil-tight flat, the between deck frames are to have a large bracket connection to the second deck stringer plate, equal in thickness to the frame's flange, with a single clip to said stringer.

42. Floor Plates.

1. All floor plates are to be secured to the center line keelson by double angle bar clips of at least 3 by 3 inches, and by a bracket plate of the same thickness as the floor plates. If said bracket plates are flanged, or have an angle bar on their diagonal edge, they may be 1/16 less in thickness than otherwise. Said brackets are to be on each side 1½ times the depth of the floors.

2. When the athwartship number is 70 and above, double zig zag riveting is to be adopted in each flange of the clips securing the floor plates and their brackets to the center line keelson or bulkhead.

3. The floor plates are to be worked up the bilge as in ordinary vessels. Floors may be worked straight on top, if brackets of the same thickness as the floors are fitted at the bilge and carried up as if the floors were turned up. When the athwartship number is below 50, said bilge brackets may be worked on alternate floors.

4. Suitable limber holes are to be cut in all floors, so as to allow of a free flow for the oil to the pumps.

43. Reverse Frames.

1. Reverse frames will be required whenever compound frames are used, as in ordinary vessels. They are all to extend to the "crown deck".

2. With bulb or Z bar frames, reverse frames are to be fitted to all floors.

3. Reverse frames may be dispensed with between decks above oil compartments, if webs or partial bulkheads are fitted in lieu of same.

44. Bottom Keelsons and Side Stringers.

1. Bottom keelsons.

(*a*) Said keelson angles may be cut at a transverse bulkhead, if the continuity of strength is maintained at said point by bracket plates of the same thickness as the keelson bars, with double clips to the bulkheads.

(*b*) When the keelson angles are 6 by 4 inches or above, said bracket plates should be flanged or have an angle bar of reverse frame size on their diagonal edge.

2. Side stringers.

(*a*) The width of the side stringers should be the same as the web frames. They can be worked intercostally between the web frames, or continuously through them, being securely connected to same at said point of intersection, as noted under web frames (Section 46).

(*b*) The side stringers are to be connected to the shell plating by intercostal angle clips of the same size as the deck stringer bars. Said clips are to be worked double for at least three frame spaces on each side of a transverse bulkhead.

(*c*) There shall be an angle bar at the inner edge of the frames. Double face angle bars are to be fitted to the inner edge of the stringer plate, worked along the diagonal edge of the bracket plates at the transverse bulkheads. Single bars of increased size may be substituted for the double faced bars. All of said stringer angles can be cut at an athwartship bulkhead.

(*d*) Side stringers 18 inches and above in width are to be supported by brackets of the same thickness as the frame's flange, spaced not over two frame spaces apart.

(*e*) When side stringers are cut at an athwartship bulkhead, bracket plates, equal to the thickness of the stringers and double clipped to the bulkhead, must be worked on both sides of said bulkhead in order to maintain the continuity of strength. The brackets are to be on each side at least three times the width of the stringer.

(*f*) When the side stringers are worked continuously through an athwartship bulkhead, the stringer plate at said point is to be increased to twice its ordinary width, with double angle bar collars, made oil-tight on each side of the bulkhead; or some other approved method is to be adopted.

(*g*) Side stringers in way of hold beams are to be ncreased in width to the width required for lower deck stringers.

TABLE 10.—BOTTOM KEELSONS: SIDE STRINGERS AND WEB FRAMES.

Number of Decks.	Bottom Keelsons.				Side Stringers. Hold Beams. Web Frames.				
	Beam in Feet.	Number.	Type of First Keelson.	Type of Second Keelson.	Depth to Upper Deck, Feet.	Side Stringers and Hold Beams. Number.	Web Frames. Width Inches.	Web Frames. Thickness 32nd.	Web Frames. Spacing Frames.
One	28	Two	DA + IP	DA	14	Two	16	10	6
	30		"	"	16	"	16	11	6
	34		"	"	18	"	18	12	6
	36		"	DA + KP	20	Three + SHB	18	14	6
	38		"	DA + IP + BP	22	"	20	14	6
	40		DA + IP + BP	"	24	Two	20	14	6
	41		"	"	26	Three	22	14	5
Two	42		DA + IP + KP + TA	"	28	"	22	15	5
	43		"	"	30	Three + SHB	22	15	5
	44		QA + DIP	QA + DIP	32	"	24	16	5

DA = Double Angles. IP = Intercostal Plate. BP = Bulb Plate. KP = Keelson Plate. TA = Top Angles. QA = Quadruple Angles. DIP = Intercostal Plate, extending above top of floors, SHB = Stronghold Beams.
Keelson plates to be in depth twice the broader flange of the keelson angle bars.

45. Floor Clips.

Lug pieces are to be fitted in way of all side stringers when bulb angle frames are adopted. If the stringers are not supported by brackets on alternate frames, said lugs must be of such a size as to take two rivets through the stringer bar. Each lug must have at least three rivets through the frame bar.

46. Web Frames.

1. Web frames are to be fitted in all vessels in way of the oil compartments or tanks, as per table 10. Their plates are to be of the same thickness as the tabular frames, and their width not less than four times that of the broad flange of said frames.

2. Double angles equal to the reverse frames are to be fitted on their inner edge, extending across top of floors to the center line.

3. Web frames may be cut at side stringers, or worked continuously at said point (the side stringers being cut). In either case quadruple clips of reverse bar size are to be fitted at said point, with a diamond plate in addition. Said diamond plates are to be in size 30 by 24 inches when the web frame is over 18 inches in width, but 24 by 20 inches when said width is 18 inches or less; the larger dimension being worked in the direction of the non-continuous member. The diamond plates are to equal in thickness the web frame plates.

4. Between deck web frames can be reduced 1/16 in thickness when of increased size and over 7/16 inches thick.

47. Deck and Hold Beams.

1. The depth and thickness of deck beams is to be the same as in ordinary vessels, except that no reduction will be allowed in the scantlings of half beams of the upper or second decks in way of oil compartments.

2. Strong beams are to be worked at the "crown deck" in way of web frames, in all cases. Said beams are to be secured to said webs by large plate brackets.

3. Beams at ends of hatches in way of oil compartments are to be of increased size, as in ordinary vessels.

4. When the deck plating is flanged in way of the expansion tanks, a fore-and-after is to be fitted in way of the half beams.

5. When the upper deck beams are cut in way of an expansion tank, they must be secured to the tank side plating by brackets of the same size as those at sides of ship.

6. Hold beams, when required (see table 10) are to be fitted in way of each web frame.

7. Beam knees in way of oil compartments (when of plate) are to be on each side at least three times the depth of the beam to which they are secured.

1. Stringers.

48. Deck Stringers and Deck Plating.

(*a*) In all cases the deck stringers are to be worked continuously through a transverse bulkhead, being worked in all other respects as in ordinary vessels.

(*b*) When the gunwale bar forms an oil-tight connection between the shell and the deck plating, it must be ½ inch larger in size than otherwise.

2. Plating.

(*a*) Steel decks to be fitted as in ordinary vessels, but in no case is the thickness of a steel deck forming the "crown deck" to be less than ⅜ inch thick, or that forming the top of the expansion trunk less than 5/16 inch thick.

(*b*) Inside of the expansion trunk it is recommended that the deck be not plated. The deck in way of both longitudinal and transverse bulkheads must be plated over for a width of at least 2 feet on each side of said bulkhead plating.

(*c*) The deck plating in way of hatches, etc., must be of increased thickness, as in ordinary vessels. When oil hatches on the upper deck are continuous, the deck plates next to them on either side must be worked double for one-half length amidships.

(*d*) The packing between top of beams and outside deck strakes to be fitted in short pieces, or washers used so as to allow for the free escape of gases.

49. Stanchions.

1. Quarter stanchions are to be fitted in each oil compartment, well riveted to floors and deck beams in all vessels of over 42 feet beam; one such stanchion being fitted when the length of a compartment is 24 feet or less, but two when said length is above 24 feet. Channel sections are recommended.

2. Heavy beams fitted with large brackets to the web frames and center bulkhead buttresses may be adopted in lieu of the quarter stanchions, if all of the transverse members are increased to meet approval.

50. Shell Plating.

1. See section 40, paragraph 1, for plate keels. Otherwise the shell plating is to be as in ordinary vessels, except that no reduction will be allowed aft up to the counter in screw steamers with machinery fitted aft.

2. All butts in way of the oil compartments should be overlapped.

51. Engine and Boiler Spaces.

1. With machinery placed aft.

(*a*) The same arrangement of side stringers and web frames as used in the oil compartments is to be used in the machinery space.

(*b*) The web frames are to be connected to the margin plates by double angles, and a gusset or half diamond plate riveted to the reverse frames and the tank side plating.

(*c*) The scantlings of all members of a water ballast tank worked under said spaces must be of increased size as for a similar tank worked amidships, as per section 25.

52. Shaft Tunnel.

Entrance to said tunnel must be by a trunkway from the main deck at both ends of the tunnel, the forward entrance being put abaft the coffer dam at the aft end of the engine room when the machinery is located amidships. When the tunnel passes through the above cofferdam, care must be taken to secure absolute oil tightness. Said tunnel must have at least two efficient deck ventilators.

53. Bulkheads.

TABLE 11.—SCANTLINGS OF LONGITUDINAL AND ATHWARTSHIP BULKHEADS.

Athwartship Number. B + D	Plating.			Horizontal Stiffeners.		Vertical Stiffeners.		
	Lower Third	Middle Third	Upper Third	Breadth and Thickness of Plates.	Size of Angles.	Size of Angles.		Maximum Spacing.
	32nd	32nd	32nd	Inches. 32nd	Inches 32nd	Inches 23rd		Inches.
42 to 45	12	11	10	9 × 11	3 × 3 × 12	5 × 3 × 12	(Angles)	24
46 " 52	13	12	11	10 × 12	3 × 3 × 12	5½ × 3 × 12	Bulb Angles	24
52 " 56	14	13	12	10 × 13	3½ × 3½ × 12	6 × 3 × 14		25
56 " 60	15	14	12	11 × 14	3½ × 3½ × 12	6 × 3 × 15		25
60 " 64	16	14	12	12 × 15	3½ × 3½ × 12	6½ × 3½ × 15		26
64 " 67	16	15	13	13 × 15	3½ × 3½ × 14	7 × 3½ × 15		26
67 " 70	17	15	13	14 × 16	3½ × 3½ × 14	7 × 3½ × 16		27
70 " 73	17	15	13	15 × 16	3½ × 3½ × 14	7 × 3½ × 16		27

1. General.

(*a*) The horizontal and vertical stiffeners of table 11 are to be worked on opposite sides of the bulkheads.

(*b*) All horizontal plate stiffeners are to have an angle bar connection of the size given in table 11, to the bulkhead plating, with a corresponding face angle at face of the stringer.

(*c*) Oil-tight bulkheads must be made oil-tight without the use of felt, packing or white lead.

(*d*) It is advisable that the bulkheads and all their stiffening angles, etc., be calked on both sides.

2. Athwartship Bulkheads.

(*a*) The horizontal stiffeners should be worked in way of the side stringers, and be well riveted to the bracket plates connecting the bulkheads to said stringers (see section 44, paragraph 2-e). The vertical stiffeners shall be secured to the floors, and to the deck at their upperend by bracket plates of the same thickness as the stiffeners.

(*b*) Said bulkheads are to have a single angle bar frame, double riveted in each flange. They are also to have a single angle bar connection to the deck plating, double riveted in each flange.

(*c*) Bulkhead shell liners are to be made of such a width as to take one row of rivets on each side, outside of the frame bars.

(*d*) A vertical web frame equal to the thickness of bulkhead plating, not less than 24 inches wide at the bottom, having face angle bars and connected to the floors and deck plating by brackets, is to be worked midway between the center line and side of ship on each side of the ship, wherever the vessel's beam exceeds 36 feet. Two such web stiffeners are to be fitted on each side wherever the beam exceeds 42 feet.

(*e*) Horizontal stiffeners of and over 12 inches wide are to be fitted with bracket knees of same thickness as the stringer, spaced not over 6 feet apart.

3. Longitudinal or center line bulkhead.

(*a*) The scantling of the plating and stiffeners it to be the same as for the athwartship bulkheads, as per table 11, except for the bottom strake, for which see Section 40, paragraph 2-a.

(*b*) The vertical stiffeners are to be spaced as are the frames, being well bracketed to the floors, and to the deck beams at their upper ends.

(*c*) Horizontal plate stiffeners should be worked in way of the athwartship bulkhead plate stiffeners, being secured to same by bracket plates of same thickness, said bracket plates being on each side (measured from the bulkhead) three times the width of the stiffener. A bracket plate of equal dimensions is to be fitted on the opposite side of the bulkhead.

(*d*) The plating of said bulkheads may be worked continuously all fore and aft, or cut at athwartship bulkheads, the latter being worked continuously. The bottom strake of plating forming the center line keelson must be worked continuously in all cases.

(*e*) The longitudinal and athwartship bulkheads are to be secured together by a single angle bar of bulkhead frame bar size, double riveted in each flange, or by double angle bars single riveted.

(*f*) At their ends said bulkheads must taper for a distance of not less than one-third the depth of the bulkhead from keel to crown of tank.

(*g*) Vertical web plates, the full height of the bulkhead, are to be worked on said bulkhead in way of the web frames at the ship's side. The plating of said webs is to equal that of the bulkhead, being not less than 2 feet broad at the foot, and have bracket plates to both floors and deck beams. The face is to be stiffened by an angle bar of reverse frame size.

(*h*) When the center line bulkhead is carried up to form a central division in the expansion trunks, it may be 1/16 inch less in thickness than the expansion trunk sides, with the stiffness of reverse bar size, spaced as are the main frames. When said bulkhead is made oil-tight in said trunks, the scantlings must be the same as the trunk sides.

4. Cofferdam bulkheads.

(*a*) Said bulkheads are to be efficiently connected together by gusset and bracket plates.

(*b*) Large bracket plates or webs must be fitted and extend down to the bottom plating against the cofferdam bulkheads outside of the oil compartments.

(*c*) No door or sluice valve shall be cut in a cofferdam bulkhead below the "crown deck."

(*d*) In two deck vessels doorways cut in the between deck spaces must be at least 18 inches above the deck bars, and have suitable water tight doors.

54. Expansion Trunks and Hatchways.

1. An expansion trunk or tank must be fitted to all oil compartments. Said tanks are to extend above the "crown deck," each tank having a capacity of at least 6 percent of that of the oil compartment to which it is fitted. The plating of said tank is to be of the same thickness as the upper part of bulkhead, as per table 11.

2. The stiffeners on both sides and ends are to be of the same scantling and spacing as the tabular frames. They are to be in line with the deck beams, being secured to same at top and bottom by bracket plates of the same thickness as the stiffeners.

3. Web frames equal in thickness to that of the trunk side plating are to be fitted in the expansion tanks at ends of all hatchways.

4. The trunk side plating is to be carried down and connected to the half beams in way of all hatches in said tanks, as in ordinary vessels.

5. Hatchways with an oil-tight metal cover must be fitted over each expansion tank, to allow of proper ventilation of said hold.

55. Butt Straps.

1. Lapped butts are recommended for the keel plate. Double straps must be fitted if butt straps are adopted.

2. The center line keelson is to have double straps when butt straps are adopted.

3. Web frames to have lapped butts to floors.

4. All shell butts are to be overlapped in way of all oil compartments. Double straps must be fitted if butt straps are adopted, with three complete rows of rivets.

56. Riveting.

1. No rivet of less than ¾ inch diameter will be allowed in an oil compartment subject to pressure. Otherwise the riveting in way of the oil tanks to be as given in table 9 and section 24, unless otherwise herein specified.

2. In oil-tight bulkheads and all other parts where the pressure comes upon both sides, and more than two plates are to be riveted together, it is recommended to adopt the flush head countersunk rivet, or the plug neck rivet. Care must be taken that the rivet heads project beyond the plate at least ¼ inch, and that there is sufficient spread on the heads to prevent them from being drawn. Pan-headed rivets, where used, must be swollen out under the neck, in order to fill the drift of the punch, and great care must be taken that each is driven up fair. Rivets in the bracket knees connecting keelsons and stringers and floors, where cut at the transverse and longitudinal bulkheads, are to be finished full or convex as in boiler work.

3. Single riveting will not be allowed in any shell plating seam in way of the oil compartments.

4. Lugs on bulb frames must have at least three rivets through the bulb frame bar.

5. There are to be not less than six rivets connecting the between deck frame stringer bracket to said frame, with the same number in each flange of the connecting angle (see Section 41).

6. The following to be single riveted:

(*a*) Butts and seams of a non-oil-tight center line bulkhead above bottom strake.

(*b*) Seams of expansion tank plating.

7. The following to be double riveted:

(*a*) Butts and seams of all oil-tight and cofferdam bulkheads (double chain).

(*b*) Lower seam of a non-oil-tight center line bulkhead.

(*c*) All oil-tight bulkhead frame bars, oil-tight gunwale bars, corner angles and collars subject to oil-tight pressure (zig zag).

(*d*) Seams of "crown deck" plating (chain).

(*e*) Butts of "crown deck" plating (treble when required).

(*f*) Butts of expansion tank plating.

(*g*) Single frame bars of all web frames (zig zag).

(*h*) Bracket plates which are fitted to maintain continuity of strength (zig zag).

(*i*) All shell plating seams in way of oil compartments (chain).

(*j*) Butts of web frames (see 8-*c* below).

8. The following to be treble riveted:

(*a*) Butts of the center line keelson throughout.

(*b*) Butts of the shell plating throughout oil compartments.

(*c*) Connection of web frames to floors.

(*d*) Brackets to stringers at bulkheads.

57. Spacing of Rivets.

	DIAMETERS.
1. (*a*) Butts and seams of expansion tank plating (single riveted)	3
(*b*) Butts and seams of deck plating forming top of expansion tank (single riveted),	
2. (*a*) Longitudinal seams of shell plating (double chain),	
(*b*) Butts and seams of all oil-tight and cofferdam bulkheads (double chain),	
(*c*) Butts and seams of "crown deck" plating,	
(*d*) Butts and seams of expansion tank plating (double riveted),	3½
(*e*) Butts and seams of deck plating forming top of expansion tank (double riveted),	
3. (*a*) All oil-tight bulkhead frame bars, corner angles and collars subject to oil pressure (double zig zag),	
(*b*) Bulkhead stiffeners, calked,	4
4. (*a*) Butts and seams of a non-oil-tight center line bulkhead above the bottom strake,	
(*b*) Beam Knees to frames,	
(*c*) Bracket plates fitted to maintain continuity of strength (double zig zag),	4½
5. Bulkhead stiffeners not calked,	6
6. Frames to shell plating and beams to deck plating	6½
7. Single frame bars of all web frames (double zig zag, each row),	7
8. Beam knees to have at least 6 rivets in each knee.	
9. Side stringer shell clips.	
(*a*) 4 by 4-inch angle bar or over; number of rivets in each flange in each frame space,	7
(*b*) Less than 4 by 4-inch angle bar; number of rivets in each flange in each frame space,	6

58. Oil Fuel Installation.

1. In all cases a settling tank must be fitted, into which the oil shall be pumped before passing to the burners, so as to separate the oil from any water which may have accidentally found its way into the tanks or pipes.

2. Wells shall be formed at the ends of the oil fuel tanks in the double bottom, in order to collect possible leakage of oil or water.

3. When an oil fuel tank is adjacent to a cargo hold, proper means (such as cofferdams) must be adopted to prevent the cargo from coming in contact with the sides of the tank, and oil wells fitted round the tank in

the cargo or machinery space, in order to collect any leakage which might find its way through the tank bulkheads into these spaces. These wells must be at least two feet deep, be separate from the hold wells or bilge, and be fitted with sounding pipes and suctions.

4. Where oil fuel tanks are close to the boilers or uptakes, special means must be taken to properly insulate the boilers or uptakes from the tanks.

5. There must be a separate pumping system to the oil tanks and wells, independent from that of the bilge or ballast tanks.

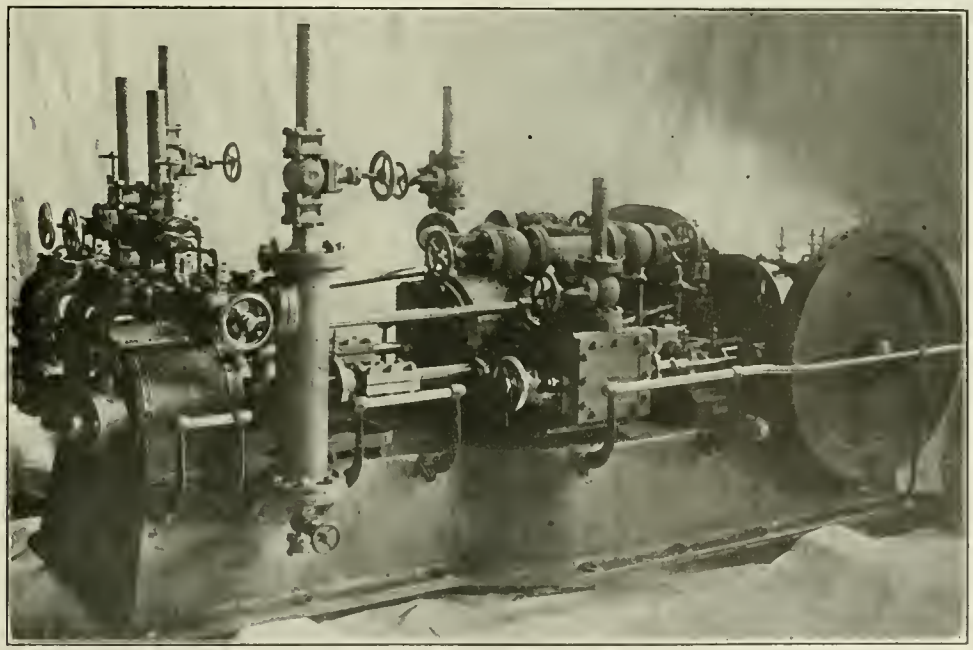
59. Compasses.

The standard compass should be at least 33 feet from any continuous current dynamo or electric motor, and 50 feet from any alternating current machine. No single wire is to be nearer a compass than 16 feet. If it is impossible to keep wires away, the double wire or concentric system must be adopted in the vicinity of the compass. Chronometers should be kept at a fair distance from dynamos and leads.

ENGINEERING SPECIALTIES.

Linde Refrigerating Plant on Creole.

The refrigerating machinery is carried on the main deck in a separate compartment just aft of the engine room hatch, with cold storage boxes for the ship's provisions on the upper deck, and cold storage rooms for carrying perishable freight on the main deck forward of the refrigerating machinery space, on each side of the engine hatch. This plant was supplied by the American Linde Refrigeration Co., of New York, and consists of the following parts: One duplex marine type machine, three sections of double pipe ammonia condenser, two brine coolers, two brass fitted duplex brine pumps, one galvanized water tank and coil for same, one brass fitted duplex water pump for the drinking water, one brass fitted duplex pump in main engine room for circulating the water through the condenser coils.



The whole arrangement of this plant is such that each room can be regulated and worked independently of the others, and to insure against a breakdown of any kind, the plant is installed in duplicate throughout and is designed to maintain a temperature of 15 degrees with cooling water at 80 degrees, when running between New York and the south. The cooling is done on the brine circulation system, with coils in the chambers, which coils are divided into six sections, each section having a main delivery and return pipe direct into the refrigerator tank rooms, which rooms are situated in the cold storage space just outside of the refrigerating engine room.

The refrigerating machine has two ten-ton double-acting ammonia compressors placed tandem to a compound steam engine, each compressor being driven by the prolongation of the steam piston rod, which is connected to the compressor piston rod by a removable and adjustable coupling. The machine is self-contained upon a massive cast iron bed-plate, placed on a pitch pine seating and bolted through the deck. The steam connections to the compound steam cylinder are so arranged that either cylinder may be run at high pressure or compound as required. The steam engine is designed for a working pressure of 150 pounds to the square inch, and when at sea, the exhaust will be carried to the main engine condenser. The ammonia connections on the machine are so arranged that each cylinder has a connection to the double-pipe condenser with pump out connections.

The double-pipe condenser is of the American Linde type, and is in three sections, so that in the event of a breakdown of one of the sections, the whole machine can operate on the remaining two, the condenser being of sufficient capacity to do this work.

There are two brine coolers, each connected to one compressor, but with the connections so arranged that either or both may be run to either or both of the compressors, or vice versa. The brine coolers consist of a heavy centrifugal wrought iron tank, with heavy water-tight cover so arranged that the circular coil can be readily removed. Each tank contains a nest of four circular coils of 1¼-inch extra heavy piping, through which the ammonia is expanded for cooling the brine. The tanks are provided with automatic air vents to pass off any gas that may be generated.

The brine circulating pumps are of the ordinary duplex brass-fitted low service type, specially designed and supplied by the Eppington Carpenter Co., of Pittsburg, Pa., and are cross-connected with each other and with each of the brine tanks in such a way that either or both may be run to either or both of the

brine tanks, if necessary, and in case of a breakdown, each pump is of sufficient capacity to handle the whole brine circulation throughout the ship.

Roller Bearings for Marine Railways.

The photograph shows an outfit of roller bearings 5 inches long, and fitted for 3½-inch axles recently made for the car trucks of a marine railway by the Bantam Anti-Friction Company, Bantam, Conn. The cages are made of the best quality of

bronze and the separating posts and rollers of the best quality of screw steel, the whole being put together in such a manner as to operate smoothly, and to have a great deal of endurance. These bearings are designed especially for the traveling cranes and the heavy car trucks to be found in repair plants using marine railways, and from all accounts have given excellent satisfaction in service.

QUERIES AND ANSWERS.

All reasonable questions concerning marine engineering received from and signed by subscribers will be answered by the Editor in this column. All communications must bear the name and address of the writer.

Q. 355.—Please give me the rule for finding the pitch of a propeller. M. G. C.

A.—To determine the pitch of a given propeller three measurements are necessary. These are:

(1) The radius OA at which the pitch is desired.

(2) The angle or part of the complete circumference corresponding to the distance on the blade between A and B, the two points between which the pitch is to be found.

(3) The advance BC along the line of the shaft, corresponding to this part of the complete revolution.

In the figure, A and B are points on the face of the blade, and are at a constant distance OA from the shaft center line OO. AC is an arc of a circle which lies in a plane through A, and perpendicular to the shaft. The angle AOC is therefore the one referred to in (2), and the distance BC is the corresponding advance. Then BC is the same fraction of the entire pitch that AOC is of a complete circle, or that the length AC is of a complete circumference with OA as radius. This complete circumference will be $6.2832 \times OA$. Hence the proportion:

$$AC : 6.2832\ OA :: BC : \text{pitch}$$

$$\text{or pitch} = \frac{6.2832 \times OA \times BC}{AC}$$

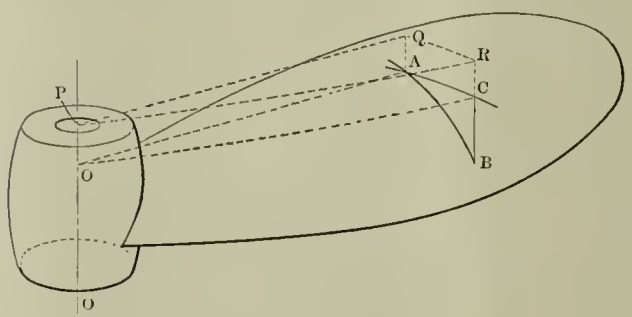
AC is however, not as easy to measure as AB, so that we may put for AC its equal $\sqrt{\overline{AB}^2 - \overline{BC}^2}$ and hence

$$\text{pitch} = \frac{6.2832 \times OA \times BC}{\sqrt{\overline{AB}^2 - \overline{BC}^2}}$$

A brief outline of the operation is as follows: (1) Select the points A and B at and between which the pitch is desired, making sure that $OA = OC$, and lay out on the blade a line AB at a constant radial distance equal to OA from the center line of the shaft. This can be done by squaring down from a straightedge or other reference line $PQPR$ placed across the hub and at right angles with the shaft. Measure the length AB.

(2) The propeller leveled up, measure the distance BC from a level through A vertically down to B. Or, if the propeller cannot be leveled, measure from B in a direction parallel to the shaft, out to a line through A and running at right angles to the shaft. Or, measure from Q down to A, and from R down to C, and take their difference, BC.

(3) Multiply the radius OA by 6.2832 and by the length BC, all in the same units of measure.



(4) Square the lengths AB and BC, subtract the square of the latter from that of the former, and take the square root of the remainder.

(5) Divide the result found in (3) by that found in (4) and the result will be the pitch desired.

Thus, for example, suppose $AB = 15$ inches, $BC = 9$ inches, and $OA = 40$ inches. Then $6.2832 \times 40 \times 9 = 2262$. Also $\sqrt{225 - 81} = 12$ and $2262 \div 12 = 188.5$ inches $= 15.7$ feet $=$ pitch.

The foregoing assumes the propeller to be of uniform pitch.

If, instead, the pitch is variable, the operation is precisely the same, but the result found must be considered merely as the mean or average value of the pitch between the points A and B. For other parts of the blade a similar process will give the corresponding pitch.

As a rough and ready rule it may be remembered that the pitch of a propeller will equal the length of a circumference at the place on the blade where the slope of the face is 45 degrees, or where it is equally inclined to the shaft and to the transverse direction. Starting near the shaft, the inclination to the longitudinal is small, but increases toward the tip. Let r be the radius where the inclination is the same to both directions. Then $p = 2\pi r = 6.2832\ r$. In this way an approximate idea may be obtained of the pitch of a wheel by estimate without special measurement, except for the radius or diameter at which the condition of equality of slope is fulfilled.

The details of the general method as described may be varied in many ways, but the description given will serve to show the general principles involved, and with a reasonable amount of mechanical skill, no trouble will be found in carrying out the measurements required.

Q. 358.—What back pressure is experienced in a motor boat without muffler, and with exhaust nozzle discharging below the water line? Is there any tendency in this case for the water to go back into the exhaust pipe and engine when the engine has been stopped?
How is an under water exhaust arranged? X. Y. Z.

A.—In a motor boat where the exhaust nozzle discharges below the waterline, the back-pressure is one-half pound for every foot of depth below the water surface at the point where the discharge nozzle is placed. Of course, where the discharge is below the water surface, there is no need for a muffler.

2. With an under-water exhaust there is a tendency for the water to go back into the exhaust pipe and into the engine when the engine is stopped and the gases cool off and form a vacuum. Under-water exhausts have to be fitted with a relief, or air valve, that will allow the atmosphere to come into the exhaust pipe the moment a vacuum begins to form. This relief valve should be placed near the engine, and may be of the automatic type, or an ordinary globe valve will serve the purpose. If the latter is used, the engineer will have to open it by hand the moment he stops the engine, which of course involves the human element of forgetfulness. On the other hand, the automatic valve sometimes sticks, and then the water is thrown into the cylinders and causes trouble.

3. The general arrangement for an under-water exhaust is an elbow or short section of pipe outside of the hull arranged to point aft; for it should be borne in mind that each explosion exerts an impulse equal to the pressure multiplied by the first velocity, and if the nozzle is pointed aft the reaction of this will tend to drive the boat ahead. If this elbow or nozzle is not fitted, and the exhaust is permitted to discharge at right angles to the boat's surface, the impulses or shocks will also be at right angles, and this sometimes sets up very serious vibration in the hull. H. J. G.

TECHNICAL PUBLICATIONS.

Marine Engineering. A Manual, by Hermann Wilda. Size, 7¼x10½ inches. Pages, 416; figures, 364; tables, 108. Hanover, Germany, 1906. Doctor Max Jaenecke, publisher. Price, $6.00 net. (In Great Britain, one pound net).

This is the text of the work which we noticed at page 162 in our issue for April. The subject is taken up in fourteen chapters, covering respectively: Ship Resistance and Engine Power; The Testing of Engines; Determination of the Indicated Power in Designing New Engines; Determination of the Cylinder Dimensions; Determination of the Thickness of the Cylinder Walls; Cylinder Fittings and Steam Pipes; Piston, Piston Rods, Cross Heads and Connecting Rods; Valves and Valve Gears; Crank Gear and Weights; Condensers; Pumps; Arrangement of Engines with regard to Spaces and Weights; Propellers; The Steam Turbine.

The text-book contains the calculations for the marine steam engine and its various parts, and is well supplemented by the index. In addition to calculations, tables are given of designs actually carried out in practice, which should be of valuable assistance in proving the correctness of new designs by comparison with approved types. Everything is thoroughly up-to-date, and well illustrated, and is given in great detail, with representative examples from German, English and American practice.

Taken in conjunction with the portfolio of plates previously noticed, the whole forms a reference book of unusual value and scope, and one which will commend itself to all designing (marine) engineers who see it.

The American Steel Worker. By E. R. Markham. Size, 5½x7¾ inches. Pages, 367; figures, 163. New York, 1906. The Derry-Collard Company. Price, $2.50.

This is the second edition of a work covering an experience of twenty-five years of actual practice in various branches of machine shop operation. This experience has taught the author that much more depends upon the condition of the various cutting tools used than is generally realized. The subjects of tempering, annealing, refining and hardening of steel are taken up in much detail, the book being profusely illustrated with devices required and being full of useful kinks. Particular attention is paid to springs, and to the general treatment of small articles, in the way of dies and reamers. The work should prove very useful to those having much to do with tools in general, and machine shop tools in particular.

Steam Turbines. By Frank Foster, M. S. Size, 5½x8½ inches. Pages, 458; figures, 249. The Scientific Publishing Company, Manchester, England. Price, 10/6 net.

In this book an attempt has been made to avoid deeply involved mathematics, and not to insist too strongly upon the attainment of the highest thermal efficiencies, it being recognized that numberless modifying practical influences invariably militate to affect the ultimate commercial result of the operation of any such piece of mechanism. In other words, it is the commercial efficiency upon which emphasis is laid. The book is not merely a popular description of existing machines, but it takes the subject up in a common sense sort of way, giving a great many practical details which affect the efficiency.

Under the heading of marine turbines, we find a number of pages, with good illustrations, of plants of various sorts and for varying purposes. The subject of friction in the turbine is taken up, as also the relation between the turbine and the propeller which it operates, and between the turbine and the condenser which provides its vacuum. The work appears to be well worthy of careful consideration.

The Analysis and Softening of Boiler Feed Water. By Edmund and Fritz Wehrenfennig. Translated by D. W. Patterson, M. E. Size, 5¾x9 inches. Pages, 290; figures, 171. New York, 1906. John Wiley & Sons. Price, $4.00.

In the translator's preface it is stated that the work of translation was taken up first for personal information, but that the data proved so practical that the book should be of considerable value to those not familiar with the chemical details of the purification of water. The Weir system of distributing the water and the displacement system of introducing the lime and soda ash solutions foreshadow desirable improvements to all types of softeners now in use in this country.

This is the second edition of the work, the special purpose of which is to give a water purifying plant a guide to the operation of its outfit, and an assistance in the installation of its machinery. It sometimes happens that in spite of the most complete chemical analysis, the purification will not always accomplish uniformly satisfactory results, because the person intrusted with its operation lacks knowledge of the leading conditions on which good results depend. It is the purpose of this book to fill a niche of this character, and to furnish the special information required for the use of the operator. The drawings are given in great detail and profusion, and show various types of plants fitted for this purpose.

Catechism on Producer Gas. By Samuel S. Wyer, M. E. Size, 4½ by 6½ inches. Pages, 42; figures, 3. New York, 1906. McGraw Publishing Company. Price, $1.00 net.

This little work contains 287 questions, with proper answers, covering a brief discussion of the types of apparatus; methods of manufacture; history; present and future uses and advantages of producer gas. It starts with basic definitions, and includes such items as the cleaning of the gas, and the handling and construction of the producer.

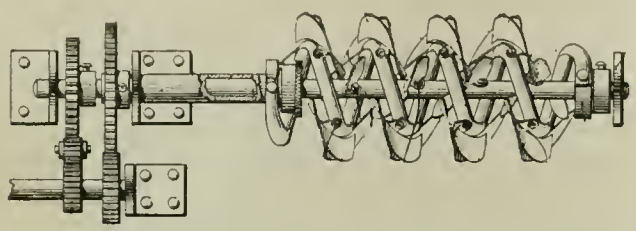
The Pacific Mail steamship *Manchuria*, of 13,638 tons, which is reported lost on one of the islands of Hawaii, is a sister ship to the *Mongolia*, illustrated on page 352 of our September number. These two ships, which were built by the New York Shipbuilding Company, of Camden, N. J., were at the time they were put into commission, two years ago, the largest vessels which had yet been constructed in the United States. It is a rather noteworthy fact that the four largest ships ever built in this country, the other two being the *Dakota* and *Minnesota*, should have been constructed on the Atlantic coast and put into operation in Pacific waters. The *Mongolia* has since gone ashore.

SELECTED MARINE PATENTS.

The publication in this column of a patent specification does not necessarily imply editorial commendation.

823,476. PROPELLER FOR MARINE VESSELS. JOSEPH DELA MAR, NEW YORK, ASSIGNOR OF ONE-HALF TO JACOB J. NICHOLS, BROOKLYN, N. Y.

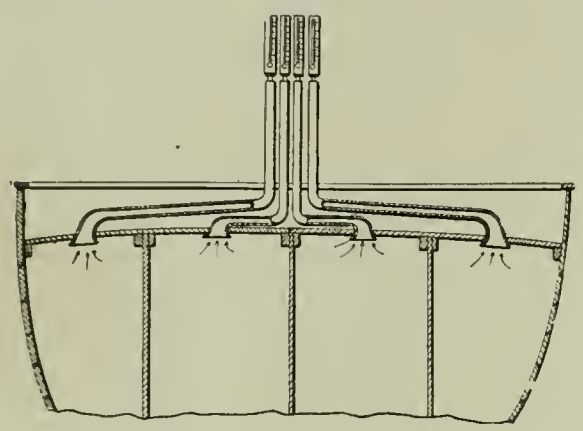
Abstract.—The improvement consists in the combination of a set of propeller-blades arranged at suitable intervals and angles on a spirally-



formed rib and another set of propeller-blades arranged within the spiral rib of the first-mentioned set, but entirely disconnected. Ten claims.

824,573. MEANS FOR PROTECTING SHIPS FROM FIRE. HAYWOOD W. McKINNE, KINSTON, N. C.

Abstract.—This invention consists, essentially, of a series of air-passages having communication with the respective compartments and converging



to a central point where thermometers are so placed as to indicate the temperature of the air circulating through the passages. Two claims.

824,726. VENTILATOR FOR SHIPS, BOATS, &c. EUGENE KOLBASSIEFF, ST. PETERSBURG, RUSSIA.

Claim.—2. Ventilator for ships, boats and the like comprising two disks having a space between them, tubes arranged in the space between said disks and a rotatably-mounted hollow spindle carrying said tubes and having openings to communicate with the interior of the ship. Seven claims.

824,727. STARTING AND MANEUVERING APPARATUS FOR TURBINE-STEAMERS. JOHN KRAFT, JEMEPPE-SUR-MEUSE, NEAR LIEGE, BELGIUM.

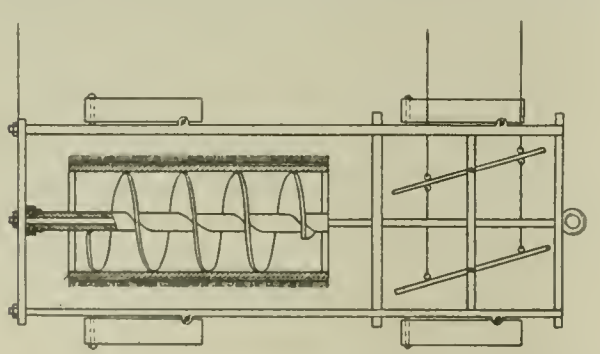
Claim.—1. A starting and maneuvering apparatus for turbine-steamers comprising a main stop-valve, for forward running, a special maneuvering-valve giving the steam access to the lateral turbines only and a single lever and hand-wheel controlling both valves, the opening of one or the other of these two valves taking place according to the direction in which the hand-wheel is turned. Four claims.

825,340. BOAT. JOHN NICHOL, MONTREAL, CANADA.

Claim.—1. A boat-shell molded from seamless felted fabric saturated in a solution of resinous substance and having seamless and jointless ends and a keel within and forming an integral part of such shell. Two claims.

826,012. MEANS FOR SCRAPING AND CLEANING THE HULLS OF VESSELS. JURGEN BEELENDORF, SUDERENDE, GERMANY.

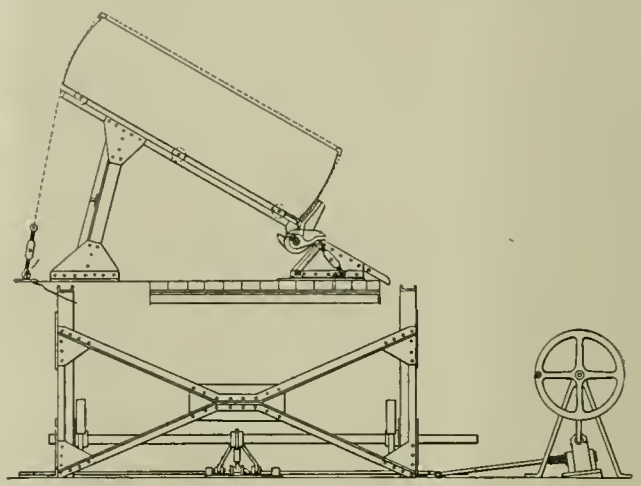
Claim.—2. Improved means for scraping and cleaning the immersed hulls of vessels during their voyage comprising a carrier-frame constructed of four longitudinal and four curved transverse bars, a centrally-supported



shaft fixed in said carrier-frame, a cylindrical shell for the reception of a rotary scraper on its exterior surface provided with a concentric nave, said nave fitting and rotatable on the aforesaid shaft, a propeller-screw fast to the nave inside the cylindrical shell, rudder-plates for raising and lowering the device in the water, adjustable presser-plates for insuring the contact between the device and the hull, means for operating the rudder-plates on board and means for holding and guiding the device alongside the vessel. Four claims.

825,017. GEAR FOR SUPPORTING AND LAUNCHING LIFE-RAFTS. HARRY MATSON, HAVRE, FRANCE.

Claim.—1. In gear for supporting and launching a life-raft, in combination, inclined guide-rails, means for supporting said rails, a rotatable



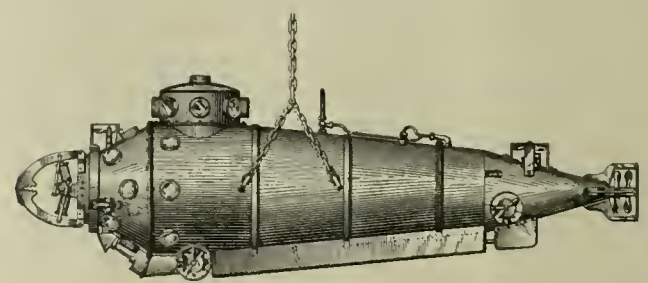
shaft mounted in suitable bearings transversely of and below said rails, triggers fast on said shaft for supporting the raft, and releasable means for controlling the rotation of said shaft. Eight claims.

826,421. BOAT. NELSON GILBERT, ALEXANDRIA, CANADA.

Claim.—1. In a boat of the class described, the combination with a body, of a cabin mounted thereon and comprising collapsible side walls and a roof, said side walls comprising sections capable of being placed within the body and covered by the roof. Seventeen claims.

826,868. SUBMARINE VESSEL. SANTIAGO NEVES, VALPARAISO, CHILE.

Abstract.—The purpose of the invention is to provide a submarine vessel adapted to contain a single individual, who is kept supplied with atmospheric air from above the water-level and who may have telegraphic or telephonic communication with attendants on the surface of the water, and to provide a simple, economic, and reliable means for propelling the boat ahead, sternward, or to starboard or port, or up or down, thus enabling

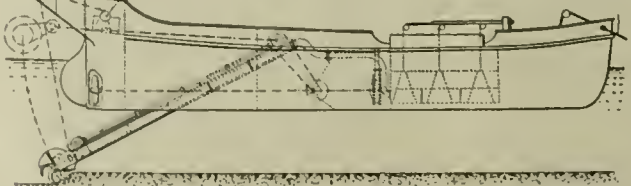


a person to descend to depths unattainable by divers having the ordinary divers' apparatus, and whereby the person in the vessel having absolute control of the vessel can move in any required direction, the vessel at its bow being provided with suitable bull's-eyes, enabling the occupant of the vessel to observe upon all sides of the vessel, as an electric light may be provided within the vessel.

Another purpose of the invention is to provide a vessel especially adapted for submarine explorations or for operating tools or tackle at points below the water being also adapted to raise heavy articles to the surface of the water or harness such objects, so that they may be otherwise raised. Six claims.

826,903. DREDGING-MACHINE. LOUIS COISEAU, PARIS, FRANCE.

Claim.—1. A suction dredging-machine having a vane-wheel bearing on the surface which is required to be dredged, a half-drum in which the vane-wheel is rotatably mounted, a suction-pipe, a pump or an ejector



connected to the upper part of the suction-pipe, an orifice provided in one of the cheeks of this drum, for receiving the lower end of the suction pipe, and an adjustable opening provided in the other cheek of the drum opposite to the suction-orifice. One claim.

International Marine Engineering

NOVEMBER, 1906.

THE FIRE-PROOF EXCURSION STEAMER JAMESTOWN.

BY ALEXANDER WILLS.

When, on June 15, 1904, the excursion steamer *General Slocum* burned to the water's edge in the East River, while carrying a Sunday school excursion, and one of the most awful calamities of our maritime history occurred in the frightful loss of life which followed, the attention of the whole country was forcibly drawn to two points, namely:

(*a*) The criminal negligence of the owners in failing to provide proper fire and life-saving equipment, and of the United States Steamboat Inspectors in failing to properly inspect the vessel and see that the requirements of the inspection service were complied with.

(*b*) The rapidity with which the ordinary type of excursion steamer can be consumed by fire, should one break out.

The persons criminally responsible for the former state of affairs were summarily dealt with, and those familiar with the instructions issued by the Steamboat Inspection Service to the Supervising and Local Inspectors regarding the rigid inspection of vessels, and with the changes in the United States Steamboat Inspection Rules relative to their equipment, can readily appreciate that a repetition of the *Slocum* disaster would be well nigh impossible, so far as loss of life is concerned.

The question of protection against fire by the use of non-inflammable materials in the construction of passenger steamers generally, and especially those of the excursion type, however, has not had the same attention paid to it. The vast majority of steamers already built, and of those building, are of the same general type as the *Slocum*, in so far as the upper structure of the vessel is concerned, and offer as little resistance to fire.

A notable exception, however, to this type is the day passenger steamer *Jamestown*, recently built by the Newport News Shipbuilding and Dry Dock Company, for the Norfolk & Washington Steamboat Company, and now running in the excursion business on the Potomac, but intended primarily for day service between Washington and Norfolk in connection with the Jamestown Tercentennial Exposition, to be held in Hampton Roads in 1907.

The idea of a fire-proof steamer for this service originated with Captain John Callahan, the general manager of the Norfolk & Washington Steamboat Co., and after competitive bids, the contract for the vessel was given to the Newport News Company, by whom the general design and details were developed.

THE NEW FIREPROOF EXCURSION STEAMER JAMESTOWN, FOR POTOMAC RIVER AND CHESAPEAKE BAY SERVICE.

The *Jamestown* is a side-wheel steamer of the familiar river type, but differs from them all in the fact that she is practically fire-proof, the first vessel to be so constructed in this country. The hull, lower and main decks, saloon and shade deck beams, all deck houses and inclosures with all divisional bulkheads, are of steel, and with the exception of the furniture, doors, windows and such fittings in the galley and pantry as could not readily be made of metal, there is no exposed wood-work. She is of the following principal dimensions:

Length over all	262 feet
Length between perpendiculars	250 feet
Beam over guards	63 feet
Beam molded	38 feet
Depth molded	14 feet 6 inches

The general arrangement of the vessel is indicated on the plans and photographs accompanying this description. From them it will be seen that the vessel has complete main, saloon and shade decks, and a lower deck forward and aft of the machinery space. Everything has been designed to contribute as much as possible

to the comfort and safety of the passengers, the vessel being intended exclusively for passenger service, the main, saloon and shade decks being devoted entirely to the passengers.

Starting with the lower deck forward the arrangement of quarters, etc., is as follows:

The fore peak up to the main deck is used to carry fresh water for boiler feed. Immediately aft of it on the lower deck is a steel chain locker extending across the vessel. Aft of this locker are quarters for the firemen and crew, with berths for eight firemen and coal passers on the port side, and for six seamen on the starboard side, with a steel divisional bulkhead between. Two staterooms for oilers and watchmen are fitted on the port side aft of the crew's quarters, and separate washroom and toilets on the starboard side, with a passage between, from which a companion leads to the main deck, with a booby hatch above. Metal berths are fitted in all these quarters, and a metal locker for each man. The deck covering in the quarters and passage is linoleum, and cement tile is laid in the washroom and toilets. Between the above quarters and the forward boiler room bulkhead a bar-room is located, which extends across the vessel. The counter in this room is built of steel, with a marble top. A wine and liquor storage room is built in the forward port corner, and a toilet with access from the bar-room is fitted on the starboard side forward. The deck is covered with interlocking rubber tiling and in the toilet room with mosaic tile. Access to the bar-room is obtained by means of an inclosed stairway from the forward end of the main deck inclosure.

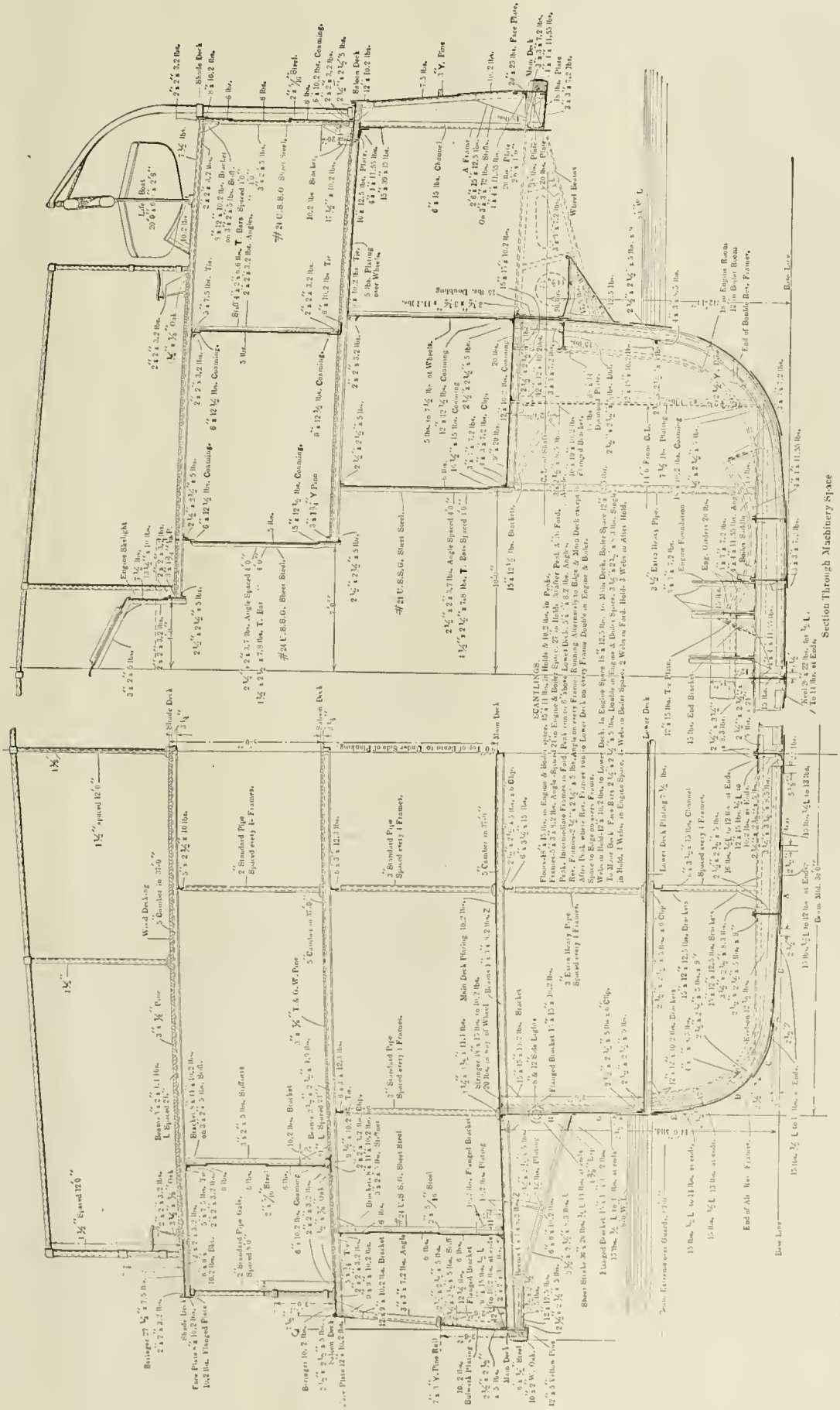
The machinery space occupies the body of the vessel amidships. In the boiler room, which is forward of the engines, the four boilers are placed two abreast with a common athwartship fireroom. Side bunkers of about 75 tons capacity are fitted the length of the boiler room, these bunkers being coaled through scuttles in the passages on the main deck. The engine room is immediately aft of the boiler room, and, below the main deck, extends the full width of the vessel. The galley is located aft of the engine room, and is very large and roomy, having a capacity for cooking for 250 people. The equipment consists in a 16-foot Duparquet range, two 36-inch broilers, refrigerator, two large sinks, dressers, etc. The galley stove-pipe is led up through a light and air shaft at the after end of the engine casing. Access to the galley other than through the pantry is by means of a stairway alongside of the purser's office on the main deck. The galley floor is covered with brick, set in cement. Aft of the galley and extending across the vessel is the pantry, with a wide stairway leading from it to the dining room on the main deck. Two steam tables, a set of coffee urns, and the usual dressers and dish racks are fitted. A storeroom for dry stores is built on the port side at the after end.

Beyond the pantry a central passage leads to quarters for the stewards' department. A large cold storage room is fitted on the port side just aft of the pantry, from which access to it is obtained. The officers' mess-room and a state-room for the stewardesses are aft of the cold-storage room. On the starboard side, quarters for the stewards' department are provided in four staterooms. The after end of the lower deck is devoted to the waiters, for whom eighteen berths are provided. Metal berths and lockers are provided for all these quarters, and the deck is covered with linoleum.

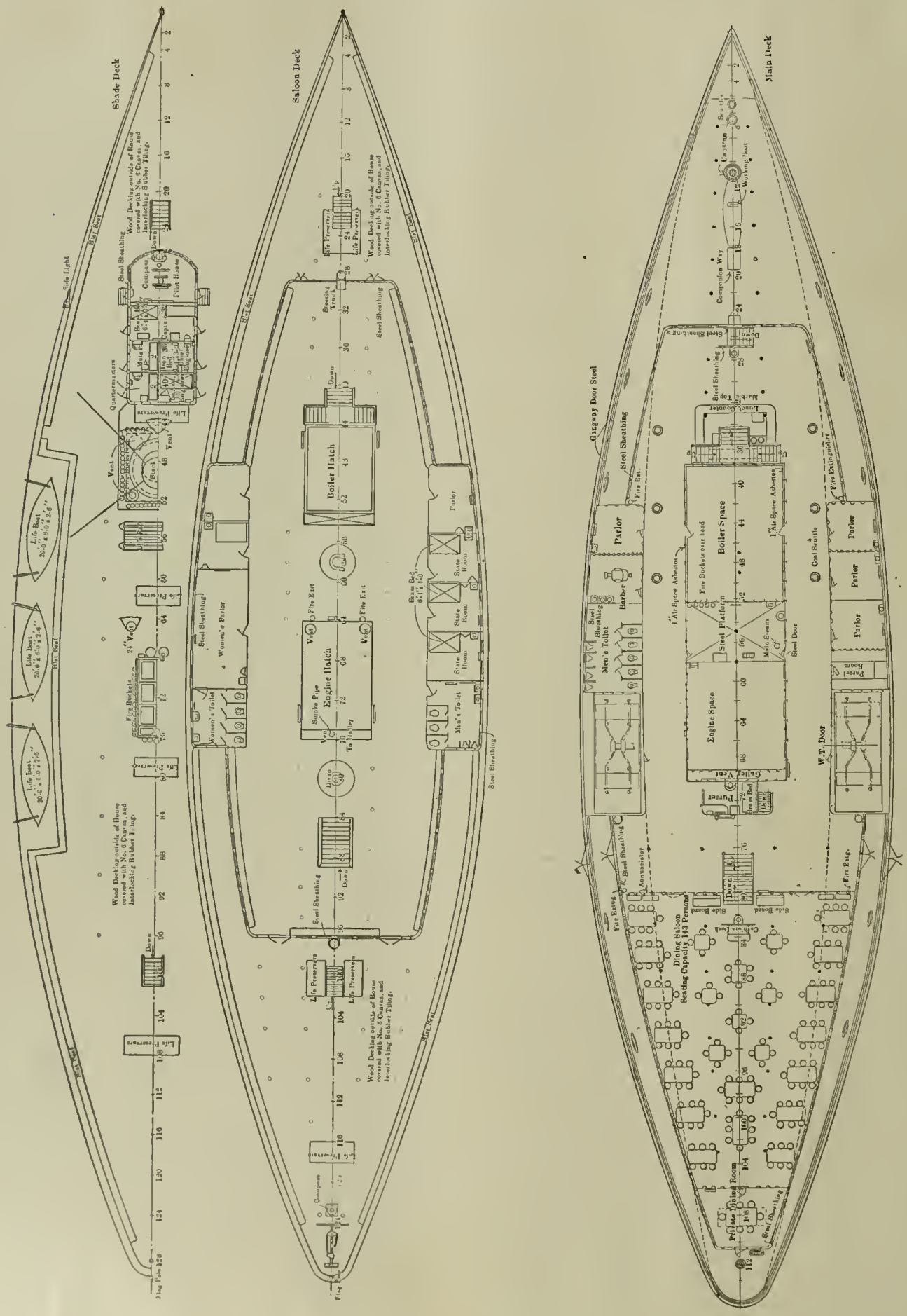
THE JAMESTOWN ON THE WAYS, JUST PREVIOUS TO BEING LAUNCHED AT NEWPORT NEWS.

On the main deck the machinery casings are 20 feet wide, and occupy the central part of the vessel. Aft of the engine casing is the purser's office and stateroom, and within the same inclosure is the stairway to the galley. The purser's office faces a large lobby, on the opposite side of which the main stairway to the upper saloon is located.

The dining room is located aft on the main deck, with a small private dining room at its after end. It is provided with a large number of small dining tables, with a total seating capacity for 143 persons, besides 10 in the private room. The dining room is entered from the lobby through double doors on each side of the main stairway.



MIDSHIP SECTION OF THE JAMESTOWN, AND SECTION THROUGH MACHINERY SPACE, SHOWING SCANTLINGS IN DETAIL.



ACCOMMODATION PLANS COVERING SHADE, SALOON AND MAIN DECKS OF FIREPROOF EXCURSION STEAMER JAMESTOWN.

In way of the machinery casings on the main deck the sides of the vessel are carried up to the saloon deck, to form inclosures for the paddlewheels, and for parlors, etc. In this space three parlors and a parcel check room are fitted forward of the wheel box on the starboard side, and a parlor, barber's shop and men's toilet on the port side. At the forward end of the boiler casing a stairway leads to the upper saloon, and forward of this stairway is a lunch counter and refreshment stand with marble top. This stairway and lunch counter are protected from the weather by an inclosure, at the forward end of which is the stairway leading to the bar. Wide passages between the machinery casings and the parlors, etc., at the sides of the vessel, lead from the forward inclosure to the main lobby. The forward portion of the main deck is not inclosed, but is protected with high steel bulwarks.

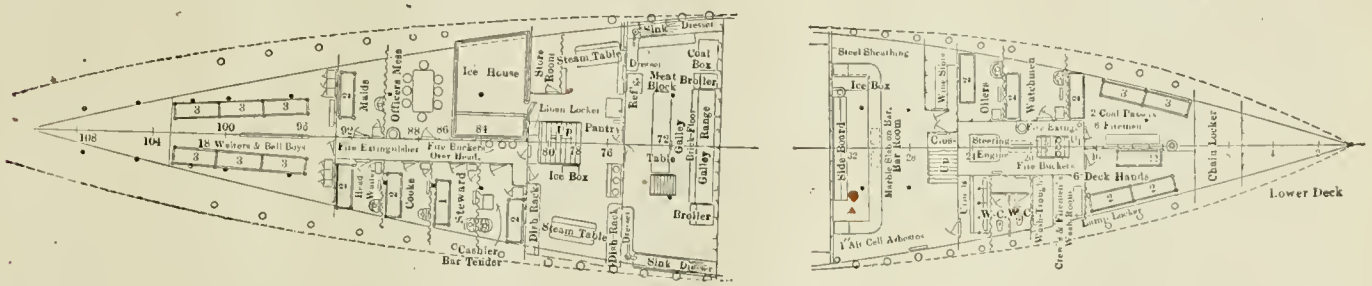
Floor covering on the main deck consists of interlocking rubber tiling on the exposed portion of the main deck forward, in the purser's office, lobby, dining room, and toilet. Heavy linoleum is fitted in the passages and elsewhere. The underside of the main deck over the engine and boiler rooms and the galley is insulated with asbestos air cell insulation.

On the saloon deck a large saloon is fitted with stairways forward and aft leading to the main deck. In it are fitted a parlor, three staterooms and a men's toilet on the starboard side, and a parlor, stateroom, women's parlor and toilet on the port side. Around the sides of the saloon leather upholstered seats are fitted, and willow rockers and chairs are scattered throughout.

Coming now to the structure of the hull, it will be seen by reference to the midship section that the form is quite full amidships, the rise of floor being small, but the bilges well rounded. The scantlings throughout were made as light as could well be, consistent with strength and stiffness, but the use of so much metal in the construction involved more weight than if wood had been used, and as the draft was limited to about 8 feet 6 inches, the section had to be made full in order to obtain fairly fine ends. The forefoot is cut away for some distance aft, but the stern is carried down in the usual manner.

The midship section illustrated herewith indicates the principal scantlings, and the general type of the construction of the hull. An inspection of it indicates that the vessel is built with a flat plate keel, a continuous center vertical keelson with continuous angles top and bottom, and floor stringers on top of the floors each side of the vertical keelson. The main framing is of the ordinary angle and reverse frame type, with floors on every frame, the spacing varying from 24 inches in the machinery space to 30 inches at the after end and 36 inches in the fore peak, where intermediate frames are fitted extending above the water line. Four web frames of plate and angle construction are fitted in the engine room and four in the boiler space, all extending to the main deck. There are also two web frames in the fore hold and three in the after hold, extending to the lower deck.

The longitudinal girders, in addition to the vertical keelson consist of a side intercostal plate keelson with double continuous angles on top of floors, and upper bilge stringer consisting of



ACCOMMODATION PLANS SHOWING AFTER END AND FORWARD END OF LOWER DECK.

Brass beds are fitted in the staterooms, the other stateroom furniture consisting of willow chairs, an oak table, mirror and toilet rack. Each private parlor is furnished with four willow chairs, a willow couch upholstered in leather, mirror, toilet rack and an oak table. Ample deck space for passengers is provided at the forward and after ends of the saloon deck, which exposed deck is covered with interlocking rubber tiling. Open stairways forward and aft leading to the shade deck.

The shade deck extends the full length of the vessel, and is covered throughout with awnings carried on pipe stanchions and ridge bars.

A raised pilot house is located forward on this deck, and accommodations in five staterooms are provided for the captain, deck officers and engineers in a deck house aft of the pilot house. The interior of the pilot house and the above deck house is lined with sheet steel, similar to that in the passenger spaces. The rails around the shade deck, as well as the saloon deck, are pipe with wire mesh panels. Slatted seats are fitted all around these decks in way of the rails. One thousand deck chairs with backs are provided for the open deck spaces.

The interior of all the passenger quarters is cork painted. The predominating color is pale green, with white trimmings in the main saloons and passages; the parlors and staterooms are each finished in an individual color. The windows in all the passengers' and officers' quarters have silk-faced pantasote sliding curtains with nickel plated fittings. Lavatories with running water are fitted in all parlors and staterooms. A complete steam heating system is installed, with radiators in all the different cabins and rooms.

double continuous angles. In the machinery spaces, where the lower deck is omitted, the stringer angle is carried through and doubled. Additional longitudinal girders are fitted in the engine spaces, to take the engine foundations, and a side stringer is fitted in the way of the wheel sponsons.

The shell plating is fitted in raised and sunken strakes, with lapped butts below the water line and butt-straps above.

Water-tight transverse bulkheads are fitted at the fore peak, the forward end of the boiler room, after end of the engine room and at the after peak. The three former extend to the main deck and the latter to the lower deck. A non-watertight bulkhead is fitted between the boiler and engine rooms, extending to the main deck. Longitudinal bulkheads are fitted the full length of the boiler room, to form side coal bunkers.

The lower deck is a flush-plated steel deck, with angle beams on every frame, and is fitted between the collision bulkhead and the forward boiler room bulkhead, and between the engine room bulkhead and the stern.

The main deck and guard beams are of Z-bar section, fitted to every frame. They are cut at the sides of the hull, and bracketed to the frames and shell by plate brackets. The main deck is flush plated throughout with No. 10 plate. Angle bar braces with flanged plate brackets connecting to the shell and to the guard face plate and under guard to stringer are fitted on alternate guard beams, excepting where the guards narrow in at the ends of the vessel, at which point plate brackets are fitted in lieu of beams. Special beams of plate and angle construction are fitted at the ends of the wheel inclosure, in way of which a heavy box girder is fitted to support the wheel eccentric bearing.

The saloon and shade deck beams are inverted angles with wood fillers. Steel stringer plates are fitted on each of these decks, and the shade deck is also plated over under the life boats. The other portions of the saloon and shade decks are decked with tongued and grooved white pine. Outside of inclosures this wood decking is covered with canvas, on which is laid interlocking rubber tiling. Within the inclosures the deck is covered with heavy linoleum, such as is used on United States naval vessels. The under side of these decks is covered with stamped galvanized sheet steel, of a simple fluted pattern, with cornices to match at the beams.

On the main deck the machinery casings extend practically the full length of the machinery space, with a divisional bulkhead between; at the forward end of the engine room the main deck plating is carried across the vessel to form the operating platform. Above the saloon deck separate casings are carried up above the shade deck level, and the engine room casing has a large metal frame skylight above, with hinged shutters operated from the platform. Windows are fitted in the engine casing on both the main and saloon decks, to give light to the passages and afford a view of the machinery. The whole of the boiler casing is insulated with ashestos air cell, held in place by sheet steel ceiling.

All deck houses, including the pilot house, and all inclosure bulkheads throughout the vessel, are of steel. The machinery casings, the passage way bulkheads on the main deck, and the inside bulkheads of the staterooms, etc., on the saloon deck, are panelled, thus adding materially to the general appearance. The divisional bulkheads between the staterooms are in general built of corrugated steel plate similar in construction to those used in naval vessels.

All stairways throughout the vessel are built of plates and angles with metal rails, the treads being covered with rubber. The interior of all cabins, staterooms, etc., in way of stiffeners, is finished with light steel ceiling, the only wood work being the window sash and doors.

For use in preventing excessive listing when the passengers are all on one side of the vessel, trimming tanks are fitted under the guards on each side forward of the wheels. These tanks are formed by plating under the guard braces, and are arranged to be filled by branch pipes from the circulating pump discharge. Drain valves are fitted in the bottom of each tank, and are provided with operating gear leading to a lever on the engine platform, the whole trimming arrangement being under the engineer's control.

The life saving equipment of the *Jamestown* consists of six 20-foot metallic life boats stowed in metal chocks on the shade deck, and swung from swinging davits, and one life raft. There are also stowed under the passenger decks and in accessible places in the saloon and elsewhere 2,550 cork life preservers.

Notwithstanding the extensive use of metal in the construction of the *Jamestown*, and the whole general fire-proof feature the fire-fighting equipment is as complete as on any excursion steamer, the United States inspection officials making no exception to their full requirement. A fire main runs to all parts of the vessel, with hose plugs located in convenient positions. Portable chemical fire extinguishers are also distributed throughout, and hand fire pumps located forward and aft.

The steering gear consists of a Williamson 6 by 6-inch double cylinder steam steering engine, located in the lower deck passage forward, connected to the steam steering wheel in the pilot house by shafting and bevel gears, and to a quadrant on the rudder stock by chain and metal rod leads under the main deck. A hand steering wheel with separate rope leads is also located in the pilot house, thus providing an emergency gear in case the steering engine is out of commission. In addition to the steam and hand gear, a hand steering gear of the Napier type is located on the saloon deck aft, and connected directly to the rudder stock.

Owing to the fact that the vessel will have a long run through Chesapeake Bay, with a liability of encountering some of the storms which occasionally trouble those waters, the anchor and cable equipment is somewhat heavier than customary on excursion steamers. There are two anchors of 1,400 and 1,200 pounds, and 90 fathoms of 1⅛-inch stud link chain, the latter stowed in a locker on the lower deck. A vertical steam windlass of the American Ship Windlass Company's make, with a capstan barrel, operated by a pair of 5 by 7-inch engines, is located on the main deck, for handling the chain.

The *Jamestown* is lighted throughout by electricity, a Sturtevant generator of 25 kilowatt capacity being located in the lower engine room. There are about 300 twenty candle power lights installed. A 14-inch Rushmore search light is fitted on top of the pilot house.

The usual means of communication is provided between the pilot house and engine room. A system of call bells from the parlors, staterooms, etc., is also provided, with an annunciator in the main lobby.

Fresh water for feed make-up is carried in the forward and after peaks, and for domestic and culinary use in two circular tanks in the lower hold aft. A fresh water pump in the engine-room draws from these tanks, and discharges into a distributing tank on the shade deck, from which is taken the supply to the lavatories. A similar distributing tank for salt water is also located on the shade deck, and connected to the sanitary pump in the engine room. This tank provides all water for flushing the toilets and urinals by gravity. In arrangement, number and general design of toilet rooms, the *Jamestown* is unsurpassed by any vessel of similar type in this country.

PROPELLING MACHINERY.

In the design of the propelling machinery another departure was made from the standard type of paddle steamer. While the majority of American side-wheel steamers have engines of the walking beam type, of late years this type of engine has been to a considerable extent displaced by inclined compound and triple-expansion engines. The latter have, as a rule, a fairly long stroke, and the diameter of the paddle-wheels does not differ materially from those in use with beam engines. In the *Jamestown* the engine is of the inclined type, but both the stroke and the diameter of wheel were made lower than in the prevailing type of inclined engines, following in this respect the English practice in channel steamers.

Another somewhat uncommon feature is the location of the wheels aft of the cylinders, the prevailing custom when the boilers are located forward of the engines being to have the wheels at the forward end of the engine room. In the model experiment it was found that locating the wheels forward would put them in a wave hollow, and with the small diameter of wheel to be used, the center of shaft would be rather low and the dip of the buckets would be excessive. These objections were overcome by reversing the positions of the cylinders and wheels, the waterline at the after position being about the normal line.*

The contract for the *Jamestown* required that she be capable of maintaining a speed of 18 miles per hour, and that the mean draft should not exceed 8 feet 6 inches. To enable them to meet this speed requirement with the least amount of power, the contractors had a model of the vessel towed in the United States model tank at Washington, and from the results of this experiment the effective horsepower required to drive the vessel at the required speed was obtained. With this as a basis, the size of the main engines was determined upon. The engine is a two-cylinder inclined compound, with 30 and 64-inch diameter cylinders, and a stroke of 66 inches.

Each cylinder with its valve chest forms a separate casting, on which are also cast flanges for bolting the cylinders to the engine foundation, and for the crosshead guides. The high-pressure valve chest is arranged to take steam in the center and exhaust

*The *Hendrick Hudson* has an inclined direct-acting engine, similarly situated.

at the ends. No liner is fitted in the cylinder, but liners are fitted for the piston valve, which is 13 inches diameter, of the plug type, with separate follower and adjustable ring.

The low-pressure cylinder is fitted with a double-ported slide valve, the valve seat having a false face. A relief frame is fitted on the back of the slide valve, and consists of a wedge shaped cast iron ring, working in a similar shaped groove on a frame, bolted to the back of the valve, the ring fitting between this frame and the valve chest cover, and having pressure applied externally by sixteen ⅝-inch steel coil springs.

Both valves are worked by Stephenson link motion with double bar links. The valve stems are of steel, the head end being guided by cast iron bonnets with brass bushings, and the crank end by cast iron guides with adjustable brass bushings. The link ends are fitted with brass bushings and steel caps. The link blocks are cast steel with brass gibs. The eccentric rods are steel with forked ends to span the links. Eccentrics and eccentric straps are cast iron.

position side gibs. Connecting rods are 148 inches long between centers, 6 inches diameter at crosshead end, 6½ inches diameter at crank end and 7¼ inches diameter at center. The crosshead end is forked to span the crosshead, and is fitted with brass bearings; the crank pin boxes are cast steel, lined with white metal.

The shaft is forged steel of the built-up type, with wrought iron cranks. Crank pins are 12 by 12 inches, secured to the inboard cranks by taper and nut, and the usual drag end type in the outboard cranks. The main shaft is 13 inches diameter in the main bearings and 14 inches diameter in the outboard bearings and in wheel centers. The outboard bearings are fitted on sponsons built outside the hull, and are cast steel pillow blocks with composition bottom box and cast steel cap, the bearings being lined with white metal. The main bearings consist of pillow blocks of cast iron, with cast iron bottom boxes, and caps lined with white metal, the whole being secured to cast steel sole pieces and securely fastened to the engine foundation. Each pillow block

THE UPPER SALOON OF THE JAMESTOWN, LOOKING FORWARD. NOTE THE QUIET SIMPLICITY.

The reversing gear consists of a steam cylinder 12 inches diameter by 18½ inches stroke, bolted to the high-pressure cylinder, and connected to the links through cast steel rocker arms provided with heavy cast iron counter weights and double forged steel suspension rods. The reverse shaft is located below the links, and is supported by the pillow blocks secured to the engine foundation. The main throttle is 10-inch diameter, of the balanced type, fitted with a 3-inch by-pass valve. The operating levers for the throttle by-pass and reversing gear are located on a platform at the main deck level, where are also grouped the levers for the drain cocks. The receiver pipe between the cylinders is steel in the main body, with copper elbows.

The high-pressure piston is cast iron, of the plug type, with separate cast iron combined follower and ring. The low-pressure piston is cast steel, with a wrought iron follower and a cast iron packing ring. The latter is in three sections, with white metal strips on the face, and is set out with steel springs excepting on the bottom, where solid distance pieces are fitted. Piston rods are 6½-inches diameter, secured to the pistons and crossheads by taper ends and nuts. All piston rod and valve-stem stuffing boxes are fitted with United States metallic packing. Crossheads are wrought iron, with double pins 6 by 7 inches, and cast iron slippers lined with white metal on top and bottom, and with com-

has a horn cast on, through which a wrought iron tie is fitted to tie the main bearings together. The cylinders and main bearings are tied together by four forged steel struts, which also form the crosshead guides. These struts are rectangular in way of the crosshead guides, and circular elsewhere. At about their mid-length, they are supported by pillars from the engine foundation. The latter is a substantial structure of plate and angle construction, with longitudinal girders the length of the engine room, and built up at the ends to suit the cylinders and main bearings.

The paddle wheels are of the feathering type, 18 feet 3 inches extreme diameter, and 17 feet diameter over the buckets. There are nine curved steel plate buckets, 3 feet deep and 9 feet wide. The wheel centers, eccentrics and bucket arms are cast steel and the wheel arms and eccentric rods are wrought iron forgings, with lignum vitae bushings. All bucket pins are forged steel, cased with phosphor bronze sleeves.

The main condenser is an independent cylindrical one, with cast iron shell and heads. The tube plates are brass, and there are 2,616 ⅝-inch brass tubes, with a total cooling surface of 3,031 square feet.

The circulating pump is of the centrifugal type, driven by a vertical 8 by 10-inch engine. The body of the pump is cast iron, composition fitted and the pump runner is composition. All

engine room pumps are independent of the main engine. The air pump is a vertical cross-connected simplex featherweight, with double cylinders 8 by 16 by 12 inches. The other pumps consist of one main feed and one donkey pump, each 12 by 8 by 12 inches, of the vertical simplex type, and one sanitary, one bilge and one feed water pump, of the horizontal simplex type, each 5½ by 8 by 7 inches.

The four main boilers are located in one compartment, with a common stokehold, and their uptakes lead into one common stack. The boilers are of the Scotch type, 12 feet 9 inches diameter by 11 feet 6 inches long built for a working steam pressure of 150 pounds per square inch. Each boiler has three 39-inch inside diameter Morison corrugated furnaces, with a common combustion chamber, and 246 3-inch tubes. The shells of the boilers are built with one course only. The total grate surface is 244 square feet, and the total heating surface 7,600 square feet, the ratio being 31.15 to 1. Dry pipes are fitted in all boilers. The stack is 7 feet diameter, and is about 64 feet high above the grates.

For discharging ashes overhead, a water-tight trunk is fitted through the bottom of the vessel at the middle of the fireroom, and extends above the water-line. To this trunk is attached a long stroke steam ash hoist, with ropes and guides for hoisting the ash buckets to the top of the trunk, into which the bucket is emptied automatically.

main boilers 15 feet 2 inches in diameter by 12 feet long; and an auxiliary boiler 12 feet 6 inches in diameter by 11 feet 6 inches long. All three were made for a working pressure of 215 pounds and all are fitted with Howden's system of forced draft.

This boiler pressure, 215 pounds, is undoubtedly a very high pressure for triple expansion engines, but the desire of the superintending engineer of the owners was to test the relative efficiency of this pressure in three cylinders, coupled with the fact of superheated steam, as against quadruple engines having the same boiler pressure. The results of the first voyage of the *Trafford Hall* were reported as very satisfactory, but with the meagre information as yet before them, the builders are not in a position to recommend this high pressure in triple expansion engines. They are, however, at present building three more vessels for the same company, all of which will have this pressure, which shows that the owners are emphatically in favor of it.

The Italian Lloyd Steamship Florida.

BY DAGNINO ATTILIO.

The *Florida* is a new type of ship for the Italian merchant marine, similar to the class of steamers that the Hamburg-American Company has in service from Genoa to New York. But if the steamships of the *Belgravia* type, luxuriously furnished

NEW STEAMSHIP FLORIDA, OF THE ITALIAN LLOYD LINE, BUILT IN GENOA.

for third class passengers, deserve the name of "freight trains" for their slow speed (12½ knots on the trial and 11 knots in normal navigation), the *Florida*, which has two large engines, and is built, as the *Belgravia*, to carry emigrants and a large cargo, is superior to the latter, owing to her higher speed.

The ship was built by the Societa Esercizio Bacini of Genoa, the hull being built at their yard at Riva Trigosa near Genoa, and the engines at the works on Genoa harbor. Four similar steamers have been built, the *Indiana* having reached New York, on her maiden voyage, February 22, 1906, with 1,500 passengers. The others are the *Louisiana* and *Virginia*.

The principal dimensions of hull and machinery are as follows:

Length between perpendiculars	370 feet 0 inches
Beam, extreme	48 feet 0 inches
Depth	38 feet 6 inches
Normal draft	28 feet 5 inches
Displacement at full load	9,000 tons

The two engines have cylinder diameters, 21¼, 33½ and 59½ inches; stroke of all pistons, 39⅜ inches. Cut-off at 0.80; 0.75; 0.62 of the stroke. Revolutions, 80. I. H. P. for the two engines, 3,000. Speed of the ship, 14.75 knots. Piston rods, diameter, 5⅜ inches. Diameter of crosshead pins, 6½ inches. Connecting rods, length center to center, 82 11/16 inches. Mean diameter of connecting rods 5 11/16 inches. Crank shafts, diameter 11 7/16 inches. Line shaft, diameter, 11⅝ inches. Thrust shaft, diameter, 11 7/16 inches. Stern tube shaft, diameter, 12¾ inches. Thrust collars, number on each shaft, 7; thrust surface, 4 square feet.

After the completion of the *Jamestown*, and before delivery to the owners, she was given a speed trial to demonstrate her seaworthiness, etc., as well as her capability of making the contract speed. The course chosen was one between Thimble and Cape Henry lights at the mouth of Chesapeake Bay, a distance of a little over 13 miles. On the run out, with the tide, the average speed was 19.93 miles per hour, and returning, against the tide, the average was 17.65 miles, or a mean speed of 18.79, which materially exceeded the contract speed. During these trials the engines worked perfectly, the average revolutions with and against the tide being 53.13 per minute.

In the *Jamestown* the owners consider they have a steamer in which the comfort and safety of the passengers has been most carefully taken care of, and the verdict of opinion is that she is a big step in advance of ordinary excursion boat construction. Her popularity on her present run augurs well for next season, when she will run between Washington and Norfolk in connection with the Jamestown Exposition. The Norfolk and Washington Steamboat Company now provide a nightly service between the above cities, but there is no day steamer from either Baltimore or Washington to Norfolk, and it is expected that the *Jamestown* will be very popular with tourists to the Exposition, as it will afford them a delightful daylight trip down the Potomac and Chesapeake Bay.

Machinery of the Trafford Hall.

The engines of the *Trafford Hall** have cylinders 24¾, 42 and 73 inches in diameter, with a stroke of 48 inches. There are two

*For description of ship, see page 188 of our May (1906) number.

There are two main air pumps, one in each engine room, worked by the propelling engines, and of single acting type, with a diameter of 18¼ inches and a stroke of 19¾ inches; two main circulating pumps worked by propelling engines, of the double acting type, 11 1/16 inches in diameter, with a stroke of 19¾ inches; four main feed pumps of the simplex, vertical, double acting, center packed, plunger type.

The main condenser for each main engine is of cast iron with a cooling surface of 2,458.5 square feet. The tubes are ¾-inch in diameter, with a length between tube sheets of 16 feet 5 inches and a thickness (No. 18 B. W. G.) of 0.49 inch. The main steam pipe has a diameter at throttle of 5⅞ inches, with a thickness of ¼-inch.

The screw propellers are three-bladed, of Stone's bronze, and turn outboard when going ahead. They are designed as true screws, and the surfaces of the blades are ground smooth with an emery wheel, and edges filed sharp. The hubs and blades are cast separately, the latter being bolted to the hub by nine tap bolts each; and the bolt holes in the palms of the blades are elliptical, to permit of adjusting the pitch. When the pitch has been set, the space between the bolts and edges of the elliptical holes is filled in with fitted composition chocks to prevent the blades from turning and altering the pitch. The diameter of the propeller is 13 feet 10 11/16 inches; pitch, mean, 17 feet 4¾ inches; pitch-ratio, 1.23; projected surface of three blades, 43 square feet.

There are five boilers of the Scotch single ended type, with a diameter of 13 feet 10 11/16 inches and a length of 10 feet 3 9/16 inches. The three furnaces for each boiler have each a mean diameter of 43 5/16 inches, with a grate surface of 60.7 square feet and a heating surface of 2,006 square feet. Ratio H. S. to G. S. 33. Working pressure, designed, 190 pounds per square inch.

The holds of the ship are capable of taking 3,600 cubic meters of cargo.

The third class accommodations provide for 1,500 passengers, in a style unsurpassed on any route. The 'tween deck spaces that remain exclusively for the emigrant's use are provided with 1,500 bunks of galvanized iron. It must be remarked that, while the governmental emigration law sets a height of 6 feet 7 inches beneath the beams, in 'tween decks, that height on the *Florida* is 7 feet 6 inches beneath the beam. The eight large quarters for the emigrants have the deadlights somewhat above the waterline when the ship is loaded, which allows for their always being opened, insuring ample natural ventilation.

COLD STORAGE ON BOARD SHIP.

PART V.

BY SYDNEY F. WALKER, M. I. E. E.

THE CONDENSER.

The condenser for refrigerating apparatus is designed to perform the same office for the refrigerant that the steam condenser does for the steam—to convert it to the liquid form. Its construction is very similar. There are two forms of condenser used in refrigerating work, the submerged, and the open. In both forms the hot gas passes through pipes, over which cooling water runs. In the submerged form, the pipes are usually in coils, in a circular tank, and the cooling water is kept continually in circulation over its surface. It is practically a surface condenser. In the open type, the pipes are usually made in grids, the cooling water being allowed to trickle down over them. The cooling effect is largely due, with the open type, to evaporation. In fact they are generally known as evaporative condensers, and are preferred on shore, wherever they can be employed, on account of their higher efficiency and the smaller quantity of cooling water required. A small portion of the water which trickles down over the pipes is evaporated, carrying off with it, approximately, 10,000 heat units for every gallon evaporated, where a gallon of water passing over the pipes in liquid form carries off only from 100 to 200 units.

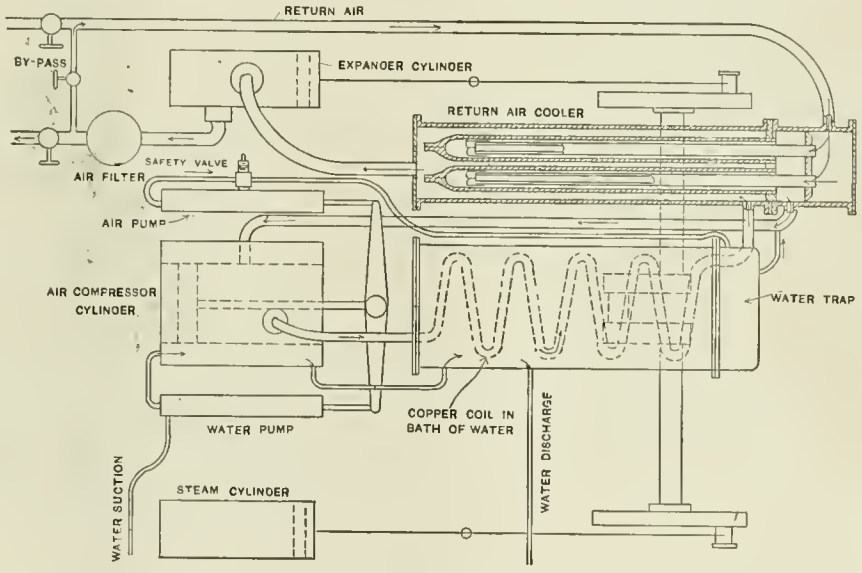


DIAGRAM OF ALLEN DENSE AIR REFRIGERATING MACHINE.

Condensers used for refrigerating apparatus are slightly different from those used for steam, mainly because it is so important that there shall be no leakage of the refrigerant. There are no joints in the pipes inside the submerged condenser. The coil is made in one long length, welded sometimes by electricity, sometimes by special lap welds, but never jointed. If joints are necessary, and where they are necessary, the pipe is brought out of the tank, and the joint made there. With open type condensers the pipes are all fitted into headers at each end. In either case, any kind of water may be used, provided that no crust is allowed to form on the outside of the pipe by the salts contained in the water. Sea water may be used, provided that this point is attended to. If a deposit is formed, a certain resistance is set up between the refrigerant inside and the cooling water outside, apart from and in addition to that of the pipe itself, with the result that the cooling water has not its proper effect, and more has to be used.

All refrigerating condensers are worked on the counter current principle, the cooling water and the hot gas circulating in opposite directions. The water usually passes from below upwards, while the hot gas enters above and passes downwards. The hottest gas meets the hottest water, and is partially cooled,

meeting colder and colder water as it passes downwards, and is itself becoming colder and colder, till at the bottom it meets the fresh and coldest water. The liquid refrigerant which is formed runs out at the bottom to a receiver, where one is used, and usually through an oil separator, to the evaporator coils.

Obviously the submerged condenser is the one adapted for ship work, but there are cases where the open condenser would do good work. It must be remembered that a current of air is of great service, especially when the air is warm and dry, as it very materially assists evaporation, and cooling with it. In the Savoy Hotel in London the cooling water for the refrigeration condenser is itself cooled by means of the equivalent of a cooling tower, fixed in the shaft which carries off the vitiated air from the chimneys, stoke hold, etc. Galvanized iron wire mats are hung in the shaft, and a fan at the bottom directs the air through them, while the water to be cooled trickles down over them. Something similar to this might be arranged on board ship for the refrigerating condenser, the coils in which the hot gas passes taking the place of the wire mats, and some of the hot air from the ship, if not too much saturated with moisture, being driven over it.

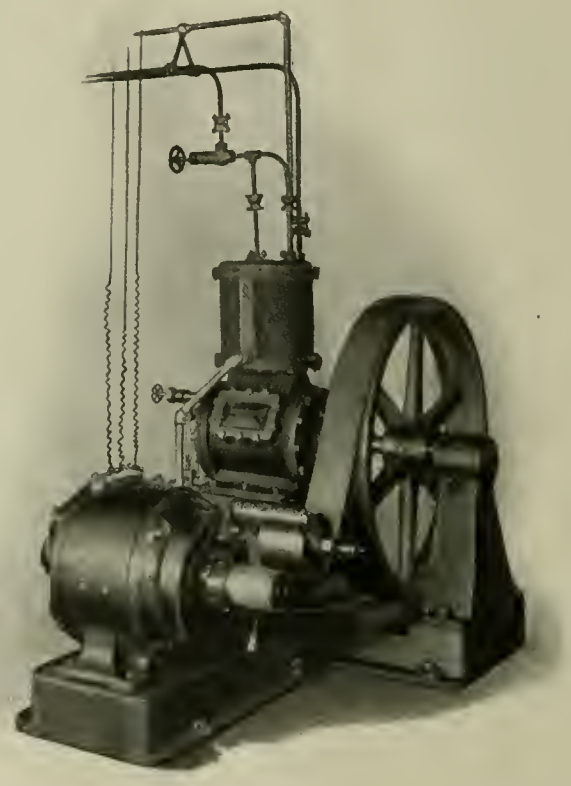
As already explained, there are three substances employed as refrigerants, ammonia, carbonic acid and sulphurous acid. All are worked upon the same lines, but the sizes of the apparatus and the pressures at which they are worked vary considerably. In addition there is another process employed with ammonia, known as the absorption process, which, after varying fortunes, appears to be coming to the front again, even for ship work. It is described below. The different agents have different latent heats, and therefore different refrigerating capacities. The capacity of any refrigerant depends upon its latent heat, that is, its ability to absorb heat in passing from the liquid to the gaseous state. This quantity is usually stated in British thermal units per pound of the refrigerant, just as that of steam is.

Perfectly anhydrous (water free) ammonia has a latent heat of 555.5 units per pound at zero F., the pressure being 30 pounds per square inch. Carbonic acid at the same temperature, but at a pressure of 310 pounds per square inch, has a latent heat of 123.2 units per pound; while sulphurous acid at the same temperature has a latent heat of 171.2 units. The latent heat varies with the temperature and pressure. The refrigerants employed have all their critical temperatures, above which they will not assume the liquid state, no matter to what pressure they are subjected. Apart from that, the temperature of the refrigerant varies with the pressure, just as in the case of steam. But as the temperature and pressure increase the latent heat decreases. Thus, at a temperature of —40 degrees F., and an absolute pressure of 10 pounds per square inch, the latent heat of ammonia is 579 units per pound, while at a pressure of 42 pounds per square inch, and a temperature of 15 degrees F., its latent heat is only 546 units per pound. Similarly carbonic acid, at a temperature of —22 degrees F., and a pressure of 195 pounds per square inch, has a latent heat of 136 units per pound, while at a pressure of 380 pounds per square inch, and a temperature of 14 degrees F., its latent heat is only 115 units per pound.

It will be observed that the latent heats are expressed in terms of pounds of the different substances, because all of these figures arising out of heat units are naturally referred to weight, since the heat unit goes by weight. But in refrigerating apparatus it is volumes that are dealt with. A certain volume of the gas which has done its work in the expansion coils is dealt with in the compressor at each stroke. Hence it is more important to know the latent heats of the different refrigerants per cubic foot, and then it will be seen that the apparent advantage of ammonia in the matter of latent heat is not maintained. One pound of ammonia measures 10.33 cubic feet at —4 degrees F., while one pound of carbonic acid, at the same temperature, measures only 0.312 cubic foot, and sulphurous acid 8.06 cubic feet. Hence the latent heat of a cubic foot of ammonia at —4 degrees is 56 units, while that of a cubic foot of carbonic acid is about 400 units at the same temperature, so that carbonic acid has the advantage.

In practice there are other matters to take into consideration, which bring the efficiencies of the three agents to about the same value. Carbonic acid is supposed to be not so efficient in hot climates as ammonia, but very good work is being done with it in India and in ships trading to the tropics. In fact, it is the refrigerant most commonly employed for ship work. Its critical temperature is 88.43 degrees F. It was supposed for some time that it would not work where water of high temperature only was obtainable. This has however been fully disproved.

It will be noticed that the pressures at which the different refrigerants are worked vary considerably. The working pressures are—for ammonia, in the neighborhood of 40 pounds per square inch in the evaporating coils, and 120 to 170 pounds in the condenser; with carbonic acid, 380 pounds per square inch in the evaporator, and 800 to 900, sometimes going very much higher, in the condenser; while with sulphurous acid the evaporator pressures are in the neighborhood of 14 pounds, and the condenser pressures about 45 pounds. It will be seen from the above how the various claims set up by the makers of different apparatus, using the different agents, are obtained.



"AUTOMATIC" 3-HORSEPOWER MACHINE WITH ELECTRIC DRIVE.

The high pressure necessary with carbonic acid is easily provided for, by mechanical construction. In the United Kingdom, Messrs. J. & E. Hall, of London, who have made a specialty of carbonic acid machinery, construct the compressor cylinder out of a solid ingot of special steel, the space for the piston, the valves, etc., being bored out with special tools at one setting. Meanwhile the high pressure and small quantity of refrigerant enables smaller compressors to be employed, a matter of considerable advantage in ship work. The makers of sulphurous acid apparatus claim, on the other hand, that their low pressures enable them to work with weaker apparatus. In practice ammonia and sulphurous acid cylinders are of about the same size.

The condenser pressure is really the delivery pressure of the compressor, while the evaporator pressure is the suction or back

pressure of the compressor. The evaporator pressure corresponds to the back pressure of a steam engine, but in contradistinction to the steam engine, it is an advantage to have the back pressure comparatively high, because it means that the gas weighs more to the cubic foot, and therefore more is taken in at each suction stroke. The work of cooling is done mainly by the conversion of the liquid into gas. Some heat is carried off by the refrigerant, after it has become a gas, but this is a small quantity, and though the cooling effect of each cubic foot of the refrigerant, when in the gaseous state, is reduced by the higher pressure and temperature, there is the gain by the greater density of the gas, as explained. As before, it is a question of a balance sheet. There is a critical value beyond which it is not economical to increase the back pressure, because the loss of cooling is greater than the gain by increased density.

LUBRICATION AND STUFFING BOXES OF COMPRESSORS.

The lubrication of compressors is an important matter, just as is that of steam cylinders. For carbonic acid machines glycerine is employed, and for ammonia machines a special lubricant that will not saponify, in combination with the ammonia itself, as nearly all of the ordinary lubricants are said to do. With sulphurous acid, the substance itself forms a good lubricator when pure, but great care must be taken that water is not allowed to penetrate to the cylinder, as then sulphuric acid may be formed, with attendant troubles. Whatever lubricant is employed other than the refrigerant itself a small quantity will mix with the refrigerant and has to be removed before the latter can be again used. For this reason all ammonia and carbonic acid apparatus is fitted with rectifiers, or oil separators, to remove the oil before the refrigerant passes to the condenser.

The separator consists of an iron cylinder having a water jacket, so that its temperature is maintained lower than that of the compressed gas it has to deal with. In the cylinder are fixed baffles of various forms, which arrest the particles of oil, and allow the purified gas to pass on. It is doubtful if the whole of the oil is removed by any of the separators, but a sufficient quantity is taken out to permit the apparatus to continue to run.

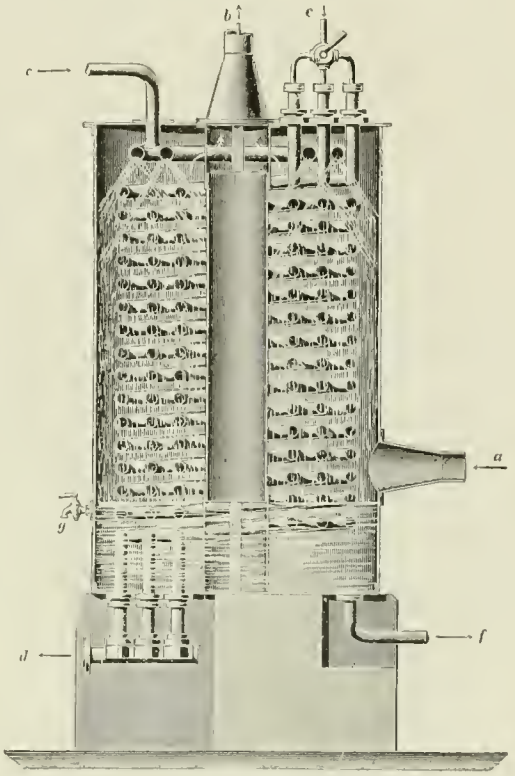
The matter of the stuffing boxes is another very important one. There are two kinds of leakage to be guarded against, that of the refrigerant out of the cylinder, which is similar to a leakage of steam from a steam cylinder, with the addition that the loss has to be made up, and that of air and moisture from outside into the cylinder. Every cubic foot of air that enters the cylinder dilutes the refrigerant to that extent, thereby lowering the efficiency of the apparatus, since a part of the power will be taken up in compressing air instead of the refrigerant gas, and the air will also occupy some of the useful space in the condenser and the evaporator, and may lead to air troubles. With ammonia, also, the refrigerant has such a strong affinity for water that any leakage of moisture into the cylinder may cause a serious loss of efficiency.

For these reasons the stuffing boxes of the piston rods of the compression cylinders are made especially long, and are packed with especial care. Usually the packing is in two sections, a distance piece separating the two, and the packing itself soaked in oil. In some forms of apparatus there is a small reservoir of oil attached to the stuffing box, and the oil is kept by various devices under the same pressure as the condenser. Messrs. J. & E. Hall have a small auxiliary cylinder, the piston of which is exposed, by means of a small connecting pipe, to the condenser pressure, the piston itself acting upon a body of glycerine held in the other part of the cylinder, while the cylinder communicates by another small passage with the stuffing box.

ABSORPTION MACHINES.

At the present time ammonia is the only refrigerant that is employed with the absorption process. The absorption apparatus takes the place of the compressor and its immediate accessories only. There is the same circuit, with modifications that will be mentioned, but the modifications are confined to parts of the absorption plant itself. There are the same condenser and evaporator, as with the compression system, and the same figures for lengths and sizes of pipes for the condenser and evaporator will rule. Also, brine is used with the absorption system, as with the compression system; and, finally, though it is called an absorption system and works by the alternate absorption and expulsion of ammonia it is really a compression system, the compression being produced by the continuous delivery of the ammonia from solution. It is also the same anhydrous ammonia that is employed to charge the machine when starting up.

The operation of the apparatus depends upon the ability of water to dissolve ammonia, whether in the gaseous or the liquid



AIR COOLER.

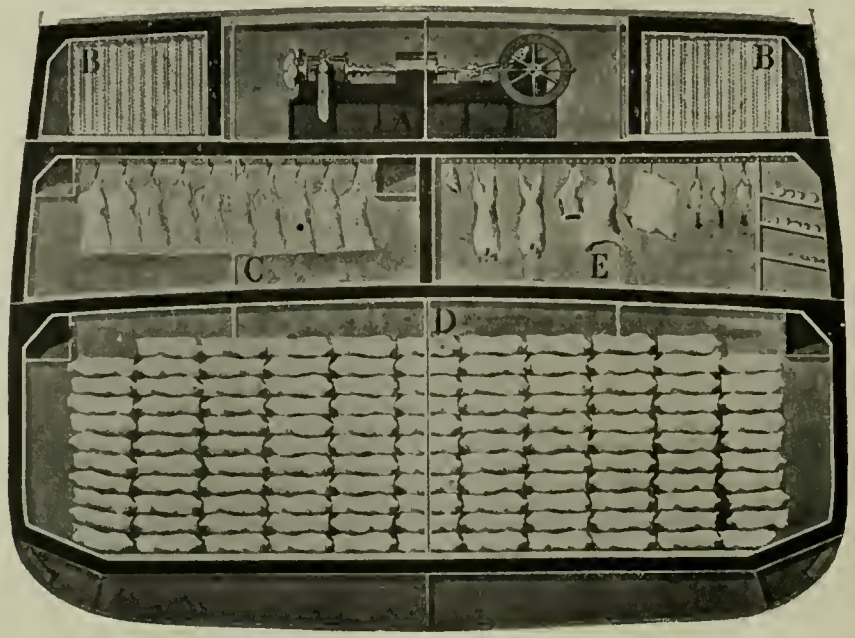
a. AIR INLET. *d.* AMMONIA OUTLET.
b. AIR OUTLET. *e.* BRINE INLET.
c. AMMONIA INLET. *f.* BRINE OUTLET.

condition. This capacity for dissolving or absorbing ammonia varies with the temperature of the water, decreasing as the temperature rises and vice versa. Further, it will be remembered that, when a gas is dissolved in a liquid, it assumes the liquid form, giving up its gaseous latent heat to the liquid.

In the modern absorption apparatus there are two principal vessels, called the generator and the absorber. The generator contains an aqueous solution of ammonia, which is kept as strong as possible, and to which heat is applied, usually by the aid of steam circulating in pipes. The absorber receives the gas which has done its work in the evaporator. The generator corresponds to the delivery side of the compressor, and the absorber to the suction side. The heat applied to the generator, by raising the temperature of the water, obliges it to expel some of the ammonia it holds in solution, the gas passing from it to the condenser, after it has been subject to certain other processes. The continual expulsion of the ammonia gas from the generator raises the pressure behind the gas that is entering the condenser, just as the continuous generation of steam in a boiler raises the pressure in the steam chest and the pipes leading from it. Sufficient compression is produced for the gas to be liquefied in the condenser, as in the compression system.

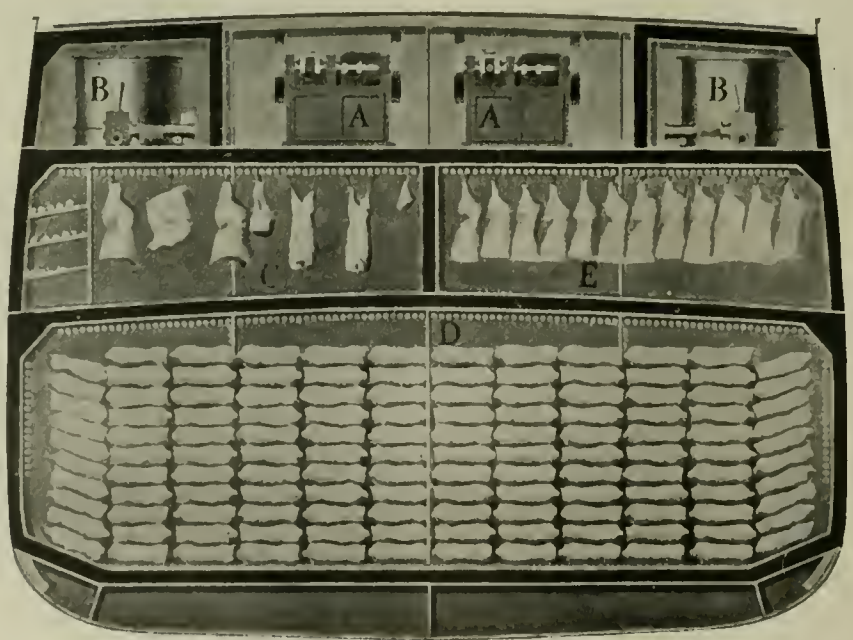
The liquid in the absorber is maintained at as low a saturation and as low a temperature as possible, in order that it may

be able to absorb all of the gas that comes over from the evaporator. In dissolving, the gas liberates the latent heat it possessed as a gas, raising the temperature of the solution. Now it will be evident that unless some arrangement is made for carrying the ammonia over to the generator as it is received, the latter will soon run down. In one form of apparatus that was on the market a short time since, the two vessels, which were in the form of cylinders, were made to perform the offices of generator and absorber alternately, the change being carried out by turning valves arranged for the purpose, after a certain number of hours' work. This arrangement has now been abandoned, and the work goes on continuously, without any change of vessels.



SECTION SHOWING APPLICATION OF AIR REFRIGERATION ON SHIP-BOARD.
a. COMPRESSOR. *b.b.* AIR COOLING CHAMBERS. *c.d.* COMPARTMENTS COOLED BY AIR; *e.* BY BRINE.

has a secondary effect, in lowering the specific gravity of the liquid. Hence the liquid from which the gas has been driven off tends to fall to the bottom of the cylinder of which the generator is composed. In the absorber the same process is going forward, but in the opposite direction, so pipes are arranged to carry off the weak liquid from the generator to the absorber, and to carry the stronger liquid from the absorber to the generator. These two liquids pass through the exchanger in separate pipes, arranged so that the hot liquid from the generator, which is on its way to the absorber, shall deliver its heat, or as much of it as possible, to the liquid that is on its way from the absorber to the generator. The exchanger, in some forms, includes also some pipes through which cooling water passes, so that the weak liquid may enter the absorber at as low a temperature as possible. But the above does not complete the tale of the apparatus required.



SECTION SHOWING APPLICATION OF BRINE PIPES TO MARINE REFRIGERATION.
a.a. COMPRESSORS. *b.b.* BRINE TANKS. *c.d.e.* COLD STORAGE ROOMS. DARK BANDS SHOW INSULATION.

The absorber is cooled by water circulating in pipes in the cylinder. Further than this, some of the heat that is not wanted in the absorber is delivered to the generator in an apparatus called the exchanger, which is an accessory to every absorption apparatus. The continual expulsion of the gas by the generator

Marine engineers are familiar with the fact that when steam

is generated, small globules of water pass over with the steam, and give more or less trouble after, if not disposed of. The same thing happens with the ammonia—some water passes over with the gas, in various forms, and must be got rid of, for the reasons already given. For this there are two pieces of apparatus, usually also in the form of cylinders, called the analyzer and the rectifier. The analyzer sometimes forms part of the generator. Both pieces of apparatus are designed to precipitate the water, however carried, and to return it to the generator.

The analyzer consists of baffles of various forms, over which the gas is made to pass on its way from the generator, and which tend to catch any globules of water held mechanically by the gas, these running back into the water from which the gas was expelled. In some apparatus, the rich liquid coming from the absorber is made to run over different obstacles on its way into the generator, meeting the hot gas that is coming away, another exchange taking place, the liquid taking up the water from the gas, and having its temperature increased. The rectifier usually consists of another cylinder, in which the gas is cooled before passing to the condenser. The temperature of the gaseous mixture is lowered to a point below that at which the water held in suspension can exist as vapor, the water being then condensed and running back to the generator.

In the latest form of apparatus made in the United Kingdom, by Messrs. Ransome and Rapier,* the apparatus consists of several cylinders, mounted horizontally, partly side by side, and partly one above the other, the condenser forming one of them. One lot of cooling water answers for the whole apparatus, passing through the different cylinders in succession. There is a small pump employed to carry the ammonia liquid from the absorber to the generator, and there will be a water pump required, where city water under pressure is not employed.

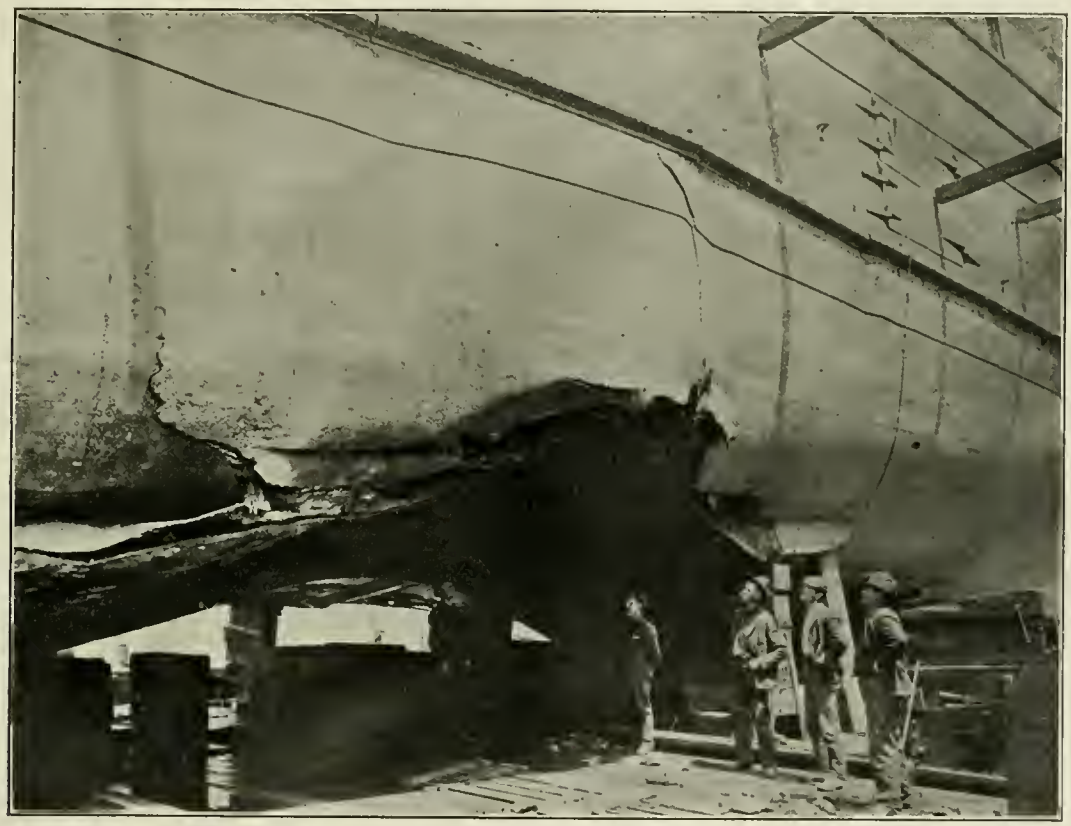
(TO BE CONTINUED.)

*32 Victoria Street, London, W., England.

Salving the George W. Elder.

The floating of the steamer *George W. Elder* on May 22, after she had been half submerged for sixteen months on a ledge of hidden rock in the Columbia river near Goble, was a triumph over difficulties that had long baffled navigators and wreckers of the northwest.

On the night of January 21, 1905, the steamer, while under charter and operated by the Portland & San Francisco Steamship Company, left Portland for San Francisco, carrying 25 cabin and nine steerage passengers, and the usual consignment of freight. The vessel did not answer her helm properly, and the wreck occurred at a point where the river makes a sharp turn. The rock on which the vessel struck is wedge-shaped, and made a jagged hole in her hull just under hatch No. 2, 84 feet from the bow, with the result that she filled with water and gradually settled on the ledge. The passengers were taken off



THE DAMAGED BOTTOM OF THE GEORGE W. ELDER, AS SHOWN IN DRY DOCK.

and brought back to Portland, but the cargo, which consisted of 1,100 tons of flour, oats, crackers, tallow, paper and other perishable materials, was a total loss, being insured for about $50,000.

After several unsuccessful attempts to float the vessel the underwriters disposed of the wreck to J. H. Peterson, of Portland, for $10,400. The services of Captain Baker, a successful wrecker from Michigan, were secured on a conditional contract, calling for $30,000 for success; nothing, in case of failure.

His first step, after a thorough investigation of the damage done to her hull had been made by divers, was to build a large cofferdam around the huge hole, which measured 36 by 8 feet, and through which the rock projected 10 feet 8 inches into the hull. The water was then pumped out of the cofferdam, and a cone of cement was built upon heavy canvas spread over the jagged rock in the hold. The cone rendered the forward hold watertight and made the work of raising the wreck possible. The element of doubt was whether the grinding and goring of the rock on which the *Elder* hung balanced would open apertures

in the cone large enough to make the inrush of water from the river greater in volume than that ejected by the pumps.

Before the pumps were started, the steamers *Harvest Queen, Ocklahama, M. F. Henderson* and the tug *John McCracken* were sent for. This wrecking flotilla was later reinforced by the tug *Colwell* of Astoria. The *Henderson* was given the lead tow, making fast to the *Elder's* stern. The *Ocklahama* and *Harvest Queen* made fast to the wreck with lines on the port and starboard bows respectively, in order to draw the bow of the vessel from shore when she righted on her keel and was sufficiently high out of the water to be released from the rocks. The *McCracken* lay astern on the starboard quarter, to keep the stern from swinging inshore onto a neighboring and menacing pile of rocks. The *Colwell's* services were enlisted to aid the donkey engine in supplying steam for the pumps. This network of towlines was reinforced by shore-lines fore and aft, while anchors were firmly set on the port and starboard bows. These precautions were necessary, owing to the swift current.

As soon as the last towline was made fast, the six pumps, throwing streams varying from 6 to 16 inches, soon lowered the water in her hold. Gradually the ship began to right herself from a list to starboard of over 40 degrees, until when released she was nearly on an even keel, though later she settled back with a heavy list, owing to the shifting of the cargo, which the wreckers had no opportunity to trim.

VIEW OF SALVAGE OPERATIONS ON THE STEAMER GEORGE W. ELDER.

For a time it looked as though the task would have to be given up, for as the water ran lower in her hold new leaks developed around the huge cement cone, and in the plate seams sprung by the goring of the rocks as the wrecked ship swung to and fro in the swift current. The wreckers went to work with renewed energy, and with a final groan the ship glided into deep water in response to the united pull of the towing fleet.

The vessel was first beached off Sand Island, in order that temporary repairs could be made. A few days later she was towed to the Port of Portland drydock, at St. Johns, a few miles below Portland, Oregon, and docked.

The *George W. Elder* was built in Chester, Pa., being launched in January, 1874, from the yards of Roach & Son. She was brought around the Horn for the San Francisco-Portland trade, and has been continually in that service, with the exception of a short time on the Alaska run.

Her length is 250 feet, the beam 38½ feet, and depth 21 feet. She is equipped with new triple expansion engines, and has a gross tonnage of 1,710, and a net tonnage of 1,225. The hull is of iron, with a spar and hurricane deck.

It is estimated that the vessel will cost its new owners $60,400; this includes cost of wreck, $10,400; cost of floating, $30,000; cost of repairs, $20,000. They have been offered $160,000 for her.

C. A. Schafer.

CONFESSIONS OF A DRAFTSMAN.

Almost twenty years ago I began to learn the shipbuilding business. I had already had considerable experience in mechanical drawing, and was fairly well advanced in mathematics. I even enjoyed the advantage of possessing the personal acquaintance of a leading ship-yard manager and a few draftsmen of prominence. Up to the present time I have designed a number of vessels and received the credit of one; if hope for a position deferred really maketh the ambitious ill, I ought to be very ill. But I am not.

Strange as this statement may seem to those not familiar with the queer ways of draftsmen, I will state that I began to offer my services with hope; perhaps, to be a little more exact, I ought to say expectation.

There is another reason why I do not look back with discouragement on my failure to have secured a position in keeping with my record and experience. I have found my experience so interesting. Its most interesting features I cannot, unfortunately, reproduce in this article; they would be too personal; they would even betray confidence. Most of all, they would make presidents and managers suspicious of me. In the first place, let me say this for them; they have nearly all been courteous; many of them favored me because they either knew me or knew about me; to others I was simply unknown.

My first experience was with the oldest, and probably the most successfully managed shipbuilding plant (up to four years ago) in this country. After seven years of a thorough training with this company, on many of the finest steam yachts, steamboats, and steamships built on the Atlantic coast, I was offered a position with a firm that had already secured the contract for building two steamers for bay and ocean service, and practically a duplication of vessels on which I had been previously engaged.

Upon my arrival at the new and finely equipped plant, I met the chief draftsman, a very tall and dignified foreigner, who passed through the drawing office so rapidly that his feet scarcely touched

the floor. He appeared to be quite clever, but had no experience whatever on this class of work. With a few exceptions, the heads of the different departments were of the same caliber. Consequently, under this administration, it required two and one-half years to complete these vessels, instead of about eleven months. At the finish, a receiver was appointed for the company, and the yard was closed for nearly five years.

I was much disappointed, but not at all discouraged, with my first experience with a new firm.

I then journeyed farther south, and was employed by a larger concern, which was the successful bidder for building three government vessels. I arrived there on a cold and dreary morning and was introduced to the head of the drafting office, a very courteous, rosy cheeked gentleman, who cross-questioned me as to my past experience, and then, with a confiding smile, related to me his experience on *tug boats*. I remained with this company two years. Seeing no chance for advancement, and the drawing office being filled with college students and house architects, I left, with the following credential, for a more northerly city with seven other draftsmen who were likewise dissatisfied.

"*To whom it may concern*:

"I take great pleasure in testifying to the ability of Mr. * * * as a first class draftsman. He proved himself to be smart, energetic and reliable while with us.

(Signed) * * *.

"Assistant Superintendent Hull Construction."

Then I was employed by a firm that was building three torpedo boats. The chief draftsman at this yard, whom I had met before, was quite tall, handsome, and a good natured gentleman weighing close to 250 pounds. (He has, by the way, risen to be one of our most successful ship-yard managers). He seemed to appreciate my work, and increased my salary two dollars more per week. In all, my experience with this company was exceedingly pleasant. They seemed to be well pleased with my services, from the tone of this note:

"*To whom it may concern*:

"Mr. * * * worked under my supervision for a period of three years, in which time he proved himself an efficient and thoroughly reliable hull draftsman, skilled in detail work and designing. He is also industrious, and can turn out a large amount of work in a short time. I take pleasure in recommending him for any position he may seek as a draftsman.

"(Signed) * * *

"Superintendent of Construction."

While working for this company, I received a letter from a former government draftsman, stating that he would like to see me on a little business matter. I called at his office the following day and found him seated in quite a comfortable looking chair, wearing a very official look, and profoundly impressive. He informed me that he had been recently appointed a constructor, and that he required the services of a draftsman capable of designing a vessel complete. After telling him of my experience, during which time he invariably stroked his mustache, I then presented my credentials, which he read with seemingly intense interest. I was appointed, and reported for duty a week later. This was my first government appointment.

Upon entering the sumptuously fitted office, I was introduced to a very gruff looking old gentleman, who had the rank and title of captain. He was seated close to a large walnut desk, smoking his pipe and reading the morning paper. Looking over his glasses with a very suspicious glare, he shook my hand tenderly, and delivered a few opinions on shipbuilding in a very authoritative manner. I listened attentively, and was then shown to a substantially built drawing board. For three years I worked over this board, and designed three vessels which were a success in every particular. The plans of same were said to be the most complete ever made in this country.

When they were finished, each one had the bold signature of the captain and the constructor in each corner, and then I was told that my services were no longer required on account of having no more work. It was really funny, as the constructor had never designed a boat, and the captain knew about as much of modern constructed vessels as I did about commanding them. To be frank, I was a little depressed, but fortunately was appointed in the Navy Department at Washington. This I expected would be a very good position, and it was.

My work was very interesting and responsible, and I remained there for three years. During that period, I was confronted, one day, by a gentleman who wore a neatly trimmed "van dyke" of unusual prominence, smoking a very black after dinner cigar, and looking quite official. He introduced himself as a ship-yard superintendent, and wished to see me in the corridor of the building. After pacing the floor and gazing at each other strenuously until I was weak in the knees, we came to terms, and I resigned my position to design a cruiser for a private firm. It is needless to say that I was ambitious. This happened to be a great firm; quite new, but with unlimited capital, and situated on the banks of a historical river where the rocks showed their hugeness at high tide. All the officers were fine fellows, and ship building seemed to be an easy thing with them.

In the drawing office, cigarettes and tobacco were sold by the blue print operator. Smoking concerts were occasionally indulged in, and nearly every one appeared as a star. It certainly was the limit. Many contracts were secured at rock-bottom prices, college boys and friends of the officials were learning to be naval architects and marine engineers at fancy salaries, and, in general, it was a good thing.

At the expiration of three months, after working nights and Sundays without extra compensation, I finished the plans of the cruisers. The design was approved by the government, and I was highly complimented by the officials. The president of the company appreciated my efforts, but the superintendent could not see his way clear to retain my services. How true it is that when we think we are impressing people with our superiority, we are nearly always arousing their contempt and disgust. Two years later, this firm failed, its liabilities being over one million dollars.

After a few weeks had elapsed, I was reinstated in the government service once more, but only to remain a short time, when I was again given a very flattering offer to take charge of the drawing office of a firm which was in the hands of a receiver—after chasing success for so long, I could not stop running.

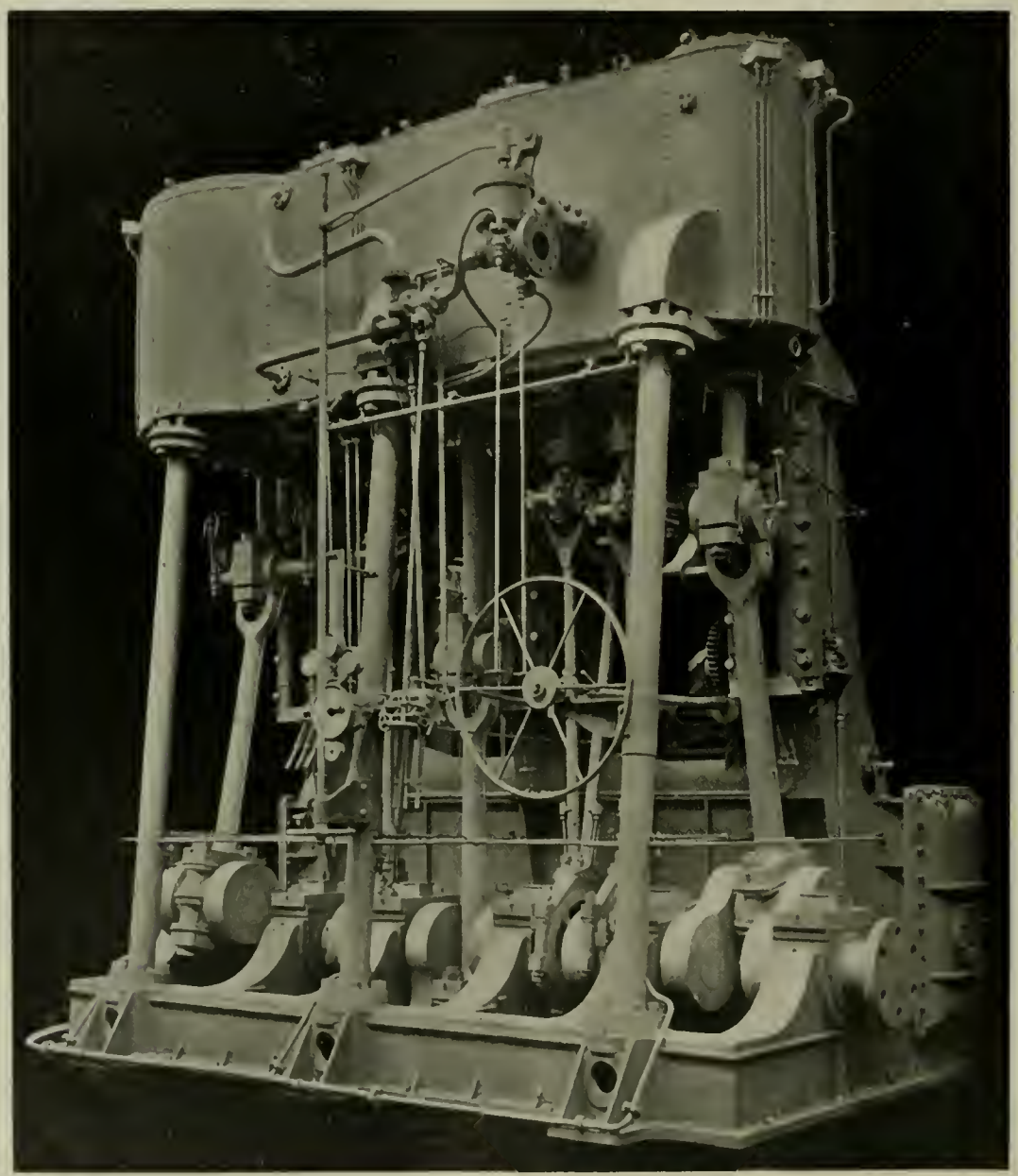
The superintendent of this plant was a hale fellow, well met, and well qualified for the position he held, and we generally agreed on every detail of the construction of all vessels. Three months later the company was reorganized.

The president, while not a ship builder, was a gentleman of great personality and a model of directness. He hit right out from the shoulder and without an apology, too. He seemed to know that a man capable of designing a vessel and asking the management to risk money in building it, ought to be able to take straight talk.

This talk, however, was too straight for the superintendent, and he took a much needed rest. I was then appointed superintendent of the plant, and at once embraced the opportunity of carrying out my ideas of building vessels economically. During the first week I occupied this position, the company was invited to submit plans of a two-hundred-foot steamer to have a speed of sixteen miles per hour, and to be delivered to the owners in seven months. The president was exceedingly anxious that the company should receive the contract, and warned me to be very careful regarding my calculations of cost, etc. The company's plans were approved, and the bid accepted.

The vessel had to finish on a draft of nine feet aft and six feet six forward, with one hundred and fifty tons of freight on board. During the summer months it was to run on probably the roughest place on the Atlantic coast, consequently was to

roll the least possible, for the comfort of passengers. In six and one-half months from the date of contract, the vessel was turned over to the owners, having met their requirements in every particular. The workmanship was considered first-class in every detail, as the vessel was built under the American Bureau of Shipping Rules for the twenty-year class. The building of a vessel of this class in a ship-yard that was at that time considered as a junk shop, compared with other yards, eclipsed all records regarding time and cost, on the Atlantic coast.



MAIN ENGINE OF STEAMSHIP BUXTON, VIEW FROM STARBOARD SIDE, FORWARD.

It was accomplished by employing as few men as possible, all of them being masters of their respective trades and professions, and the abolishing of the "red tape" methods which are now in vogue in our new shipbuilding plants. The drafting office force, which I consider the backbone of every ship-yard, was composed of experienced men; they were paid first-class wages, and their work was eminently satisfactory.

I was complimented by the president on my administration, and promised a block of stock in the company at an early date. I was continually being made such promises, and after working late almost every night and many Sundays for over a year, my position was transferred to a gentleman of great influence with the president, and I was offered a lower position. This change was not at all agreeable to me, and I resigned. The president seemed to feel sorry, and handed me the following testimonial:

"*To whom it may concern*:

"I take pleasure in recommending Mr. * * * as a hull draftsman of ability and skill and of wide experience for a man of his years in the line of his profession. Mr. * * * was in the employ of the A. B. C. for a year, when he resigned, and designed the steamer D. E. F., recently built by the company for the G. H. I. Railroad Company of J. K. L., which vessel is a credit to her builders, as well as a satisfaction to her owners. To any firm needing the services of a capable designer and resourceful draftsman, who combines this with celerity in his work, I recommend Mr. * * *.

Very respectfully,

"(Signed)

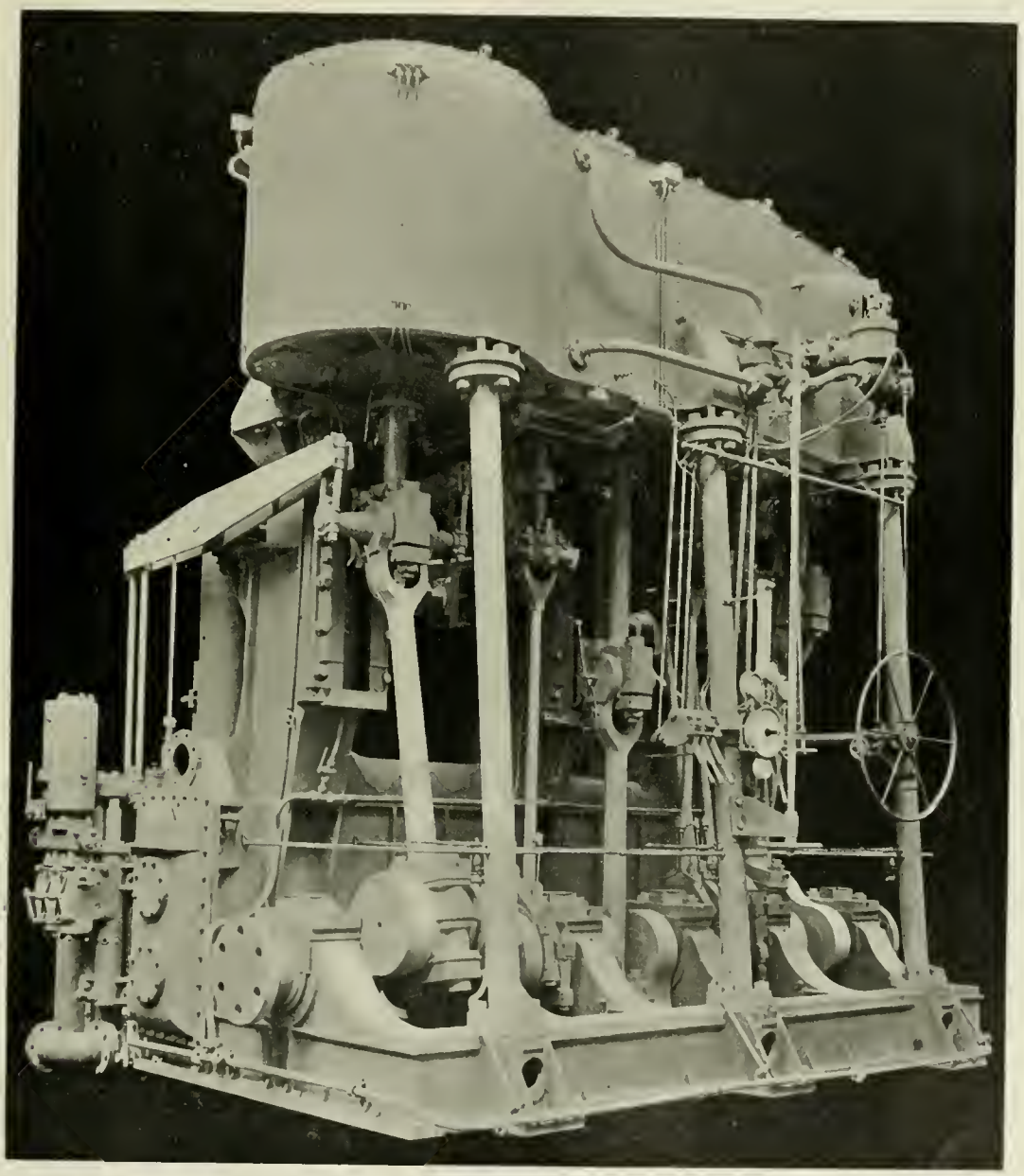
"President X. Y. Z. Shipbuilding and Dry Dock Co."

This firm failed eighteen months later.

Shipbuilding at this time was at a very low ebb. I applied to

the various ship-yards for a position, but there were no vacancies. The government, however, decided to build a battleship in a navy yard, and I succeeded in securing an appointment at $1.00 per day less than I received four years previously in the same department. This position was subject to an examination at the expiration of thirty days. I took the examination, being examined by two dashing young naval officers. This examination was attended by thirty applicants and lasted three days. So confusing were the first few questions that twelve draftsmen left the room never to return, and by the evening of the first day, only ten applicants remained. The evening of the second day found me with seven more haggard and worn looking men struggling with problems that we had never used in all the years of our experience. The most distressing scene, however, was a draftsman of over twenty-four years' experience who had held the position of naval architect for eight years with one of the largest shipbuilding companies in this country, at a salary of three thousand five hundred dollars per year. He was tugging along with a launching calculation, and I learned later that he was appointed at $4.48 per diem. Having passed the examination, I worked along under a strain of humiliation. In this office there were many men who had never passed an examination, who did not even possess one credential; one man especially who could hardly speak the English language correctly was receiving one dollar per day more than myself. It was whispered that they had a "pull," and thereby hangs a tale. After the most important work on the battleship had been designed and the material ordered, seven of the best talent resigned.

The famous Shipbuilding Trust offered me a better position in one of its local plants, which I accepted. In a few months I was promoted to the position of chief draftsman. Prosperity seemed to haunt me; I could see visions of a bank account. But not for long. The Shipbuilding Trust failed, and this plant was shut down. I lost my position, and was "down and out."



MAIN ENGINE OF STEAMSHIP BUXTON, VIEW FROM STARBOARD SIDE, AFT

At times when I reflect on my devotion to my profession, I am so amused that I feel like laughing aloud. I see other men, some of them utterly without experience and without even the faculty of designing a mud scow, and yet pleasing the ship-yards at enormous salaries. I wish that it were in my power to write as enthusiastically of the administration of our ship-yards as I would like to do; but it would take an optimist, indeed, and a base prevaricator at that, to throw a roseate hue

over the shipbuilding industry as it stands at the present time.

Shipbuilding in America to-day is stagnant, on account of the inexperienced men who have been introduced into its dealings during the past eight or ten years. This is an adequate explanation as to why receivers have been appointed for many companies. There is exceptional talent in this country, which, if it was placed at the heads of ship-yards, would make them a success; but we find most all of these positions filled by men of little or no experience, influence seemingly being the required qualification. For instance, several of our new ship-yards find no difficulty in explaining results of contracts, because they start out with psychological theories, and determine the results of their methods by a process of reasoning. They state, for instance, if such and such methods are used, such and such results must follow; but the results which they explain by their methods are the products of their own imaginations. When, however, we come into possession of the real facts, we find that they differ widely from imaginary ones, and the result has been bankruptcy.

Throughout the history of American shipbuilding, it is doubtful if there has been one part of the subject upon which views have been so diverse as upon the proper policy with regard to administration of our ship-yards. This has been due to two chief causes; first, a lack of knowledge of the facts, and, second, a genuine difference of opinion with an admitted basis of fact. With regard to the first cause, the facts are in existence, but no one knows them with sufficient breadth or completeness to make possible a really intelligent discussion of the problem, except the practical marine architect and engineer who has been constantly engaged in designing our ships and the details involved in their construction. These men are commonly known as "draftsmen," and the work dependent upon them constitutes the calculations of cost, displacement, stability, speed, etc., as well as the ordering of material. The designing of every ship is a problem by itself, and the draftsman's work is always one of adaptability, while difficulties must be met and overcome in every new contract. Yet they seem to be the least appreciated, and receive comparatively little reward except the satisfaction of well doing when a vessel is a success. The average salary of a draftsman is $3.50 per day. Indeed the managers of many concerns pride themselves upon the fact that the money they have made out of the draftsman's toil enables them to look down upon them as individuals of a distinctly lower grade.

On the other hand, the draftsmen have only themselves to blame for this condition of affairs. They are not organized; hence they are tossed about at the shipbuilder's will from the Atlantic to the Pacific, and vice versa, seldom stopping more than two years in any one ship-yard.

There was a time, five years ago, when a bill was before Congress creating a staff of naval architects. This bill was for the benefit of the draftsmen in the Bureau of Construction and Repair, Navy Department, Washington. Admiral Hichborn, who was at that time chief constructor of the United States navy, testified before the House Committee on Naval Affairs, in behalf of the draftsmen, stating that they were the men that executed the plans for all our warships, and that the bill had his hearty support. But the bill did not become a law, and thereby hangs another tale.

As I have gone on writing, I am afraid I have not maintained the tone of amiability adopted at the beginning of this article. I have a great horror of seeing myself disappointed. However, a disappointed success is far worse than a failure not yet accepted. In the first case, utter hopelessness follows; whereas, with failure resisted, there is always hope. I suppose I am one of those people who never know when they are beaten. Perhaps I was beaten years ago. But, as a matter of fact, no persevering worker is really beaten until he dies or loses his capacity for trying.

C. G.

THE STEAMSHIP BUXTON.

The new steel screw steamer *Buxton*, built by William Gray & Company, Limited, West Hartlepool, for H. Samman & Company of Hull, England, to the highest class in Lloyd's Register, has a length over all of 342 feet, a breadth of 47 feet 6 inches and a depth of 24 feet 9 inches. The ship has a long bridge, poop and topgallant forecastle, with saloon, state rooms, captain's, officers' and engineers' quarters and houses on the bridge deck, and crew accommodations in the forecastle.

THE STEAMSHIP BUXTON ON TRIAL TRIP.

The hull is built with deep frames, and with a cellular double bottom and after peak ballast tank. The equipment includes five steam winches, steam and hand steering gear, steam windlass and donkey boiler, stockless anchors, telescopic masts and all requirements for handling cargo.

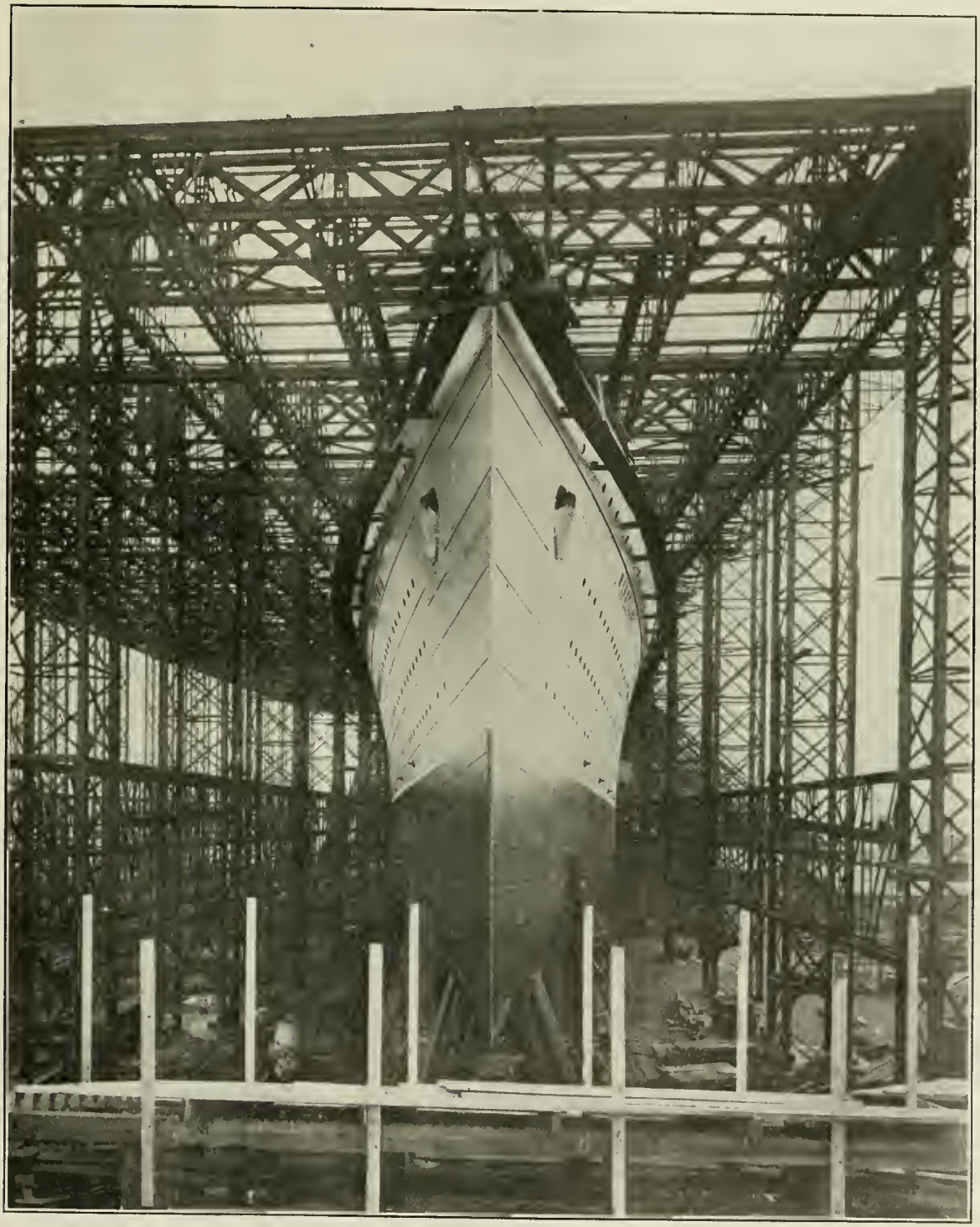
The triple expansion engine, supplied by the Central Marine Engine Works, has cylinders with diameters of 23½, 38 and 64 inches, and a common stroke of 42 inches. Steam at a working pressure of 180 pounds per square inch is supplied by two large boilers. See pages 434 and 435.

The Greater Safety of Alcohol as compared with gasoline for commercial uses is due to the fact that it will not ignite from pure radiated heat as gasoline does; that water will extinguish burning alcohol while it will only spread a fire of gasoline, and that the flame of burning alcohol radiates very little heat while that of gasoline radiates heat very rapidly.

THE NEW CUNARDER MAURETANIA.

BY BENJAMIN TAYLOR.

The second 25-knot Cunarder—the *Mauretania*—launched on the Tyne, Scotland, in September, is sister ship of the *Lusitania*, launched in June at Clydebank, and described in our August number, but there are some notable differences which, although not mentioned elsewhere, may be noted in these pages.



BOW VIEW OF THE MAURETANIA IN THE BUILDING SLIP AT WALLSEND-ON-TYNE.

The *Mauretania* is, for instance, of 6 inches greater depth than the *Lusitania*, and her gross tonnage is 700 tons more, or 33,200 tons, and net 11,900 tons. Her length is the same as the *Lusitania* —785 feet, and her beam 88 feet. She will carry 560 first-class passengers, 500 second-class passengers, and 1,200 third-class. She is 100 feet from keel to sun-deck, and her launching weight was 16,500 tons. The sun deck is the ninth deck, and six of the nine decks are devoted entirely to passenger accommodation. The lower part of the ship is taken up with machinery, stores, etc. The general height between decks is 9 feet, but in the dining saloon, restaurants, cafés, and public rooms it is 10 to 11 feet.

In Atlantic liners the side of the hull amidships inclines inwards towards the top, thus reducing the width of the upper decks. In the *Mauretania*, however, brackets have been formed on the ordinary stanchions, and the promenade decks extend outwards, corresponding to the width at the water line. This promenade space on each side of the deck houses is thus increased to 18 feet.

In general structure the *Mauretania* corresponds with the

Lustitania. The double bottom is 5 feet deep, the bottom is flat, but rounded at the bilge; there are bilge keels 3 feet in depth, extending for a quarter of the length of the vessel. The plating is heavy, some of the plates weighing four tons, and special attention has been paid to strength in the double bottoms and along the sides. High tensile steel has been used, and the joints are covered with heavy straps with eight rows of rivets.

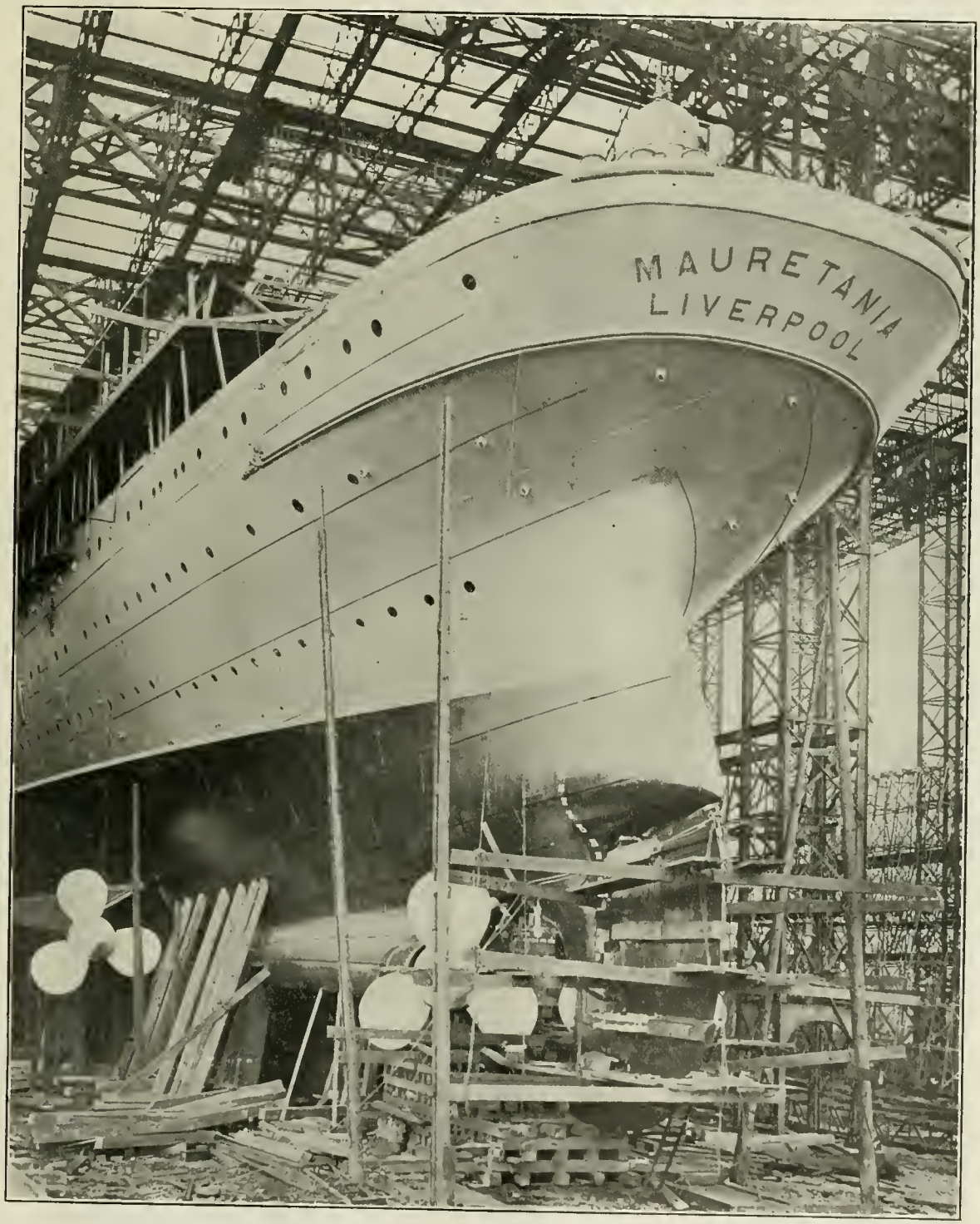
THE SET OF UPSTAKES FOR ONE FUNNEL, AS SET UP IN THE BUILDERS' YARD.

The general arrangement of the turbines corresponds with that in the *Lusitania.* There are four sets, each driving a shaft with a single three-bladed propeller, differing, however, in proportion from those of the *Lusitania.* The two outer shafts, which turn inwards when going ahead, are fitted with high-pressure turbines; the two inner shafts, which turn outwards, have low-pressure turbines, and also have the astern turbines, which are entirely separate from the ahead turbines. In the turbines of the *Mauretania,* a further difference is to be noted in the material used. The casings throughout are of cast iron, but the rotors and their disk ends are forged of Whitworth's fluid compressed steel. The high-pressure turbine is 26 feet in length. The astern casing is entirely separate from the low-pressure casing, and the adjustment block is between them. The rotating mass in the low-pressure and astern casing is over 200 tons, and is arranged to enable an adjustment of 1/3000 inch to be made. The maximum peripheral speed is 10,000 to 11,000 feet per minute, with a minimum clearance of 1/10 inch in the high-pressure turbine between the blades and their proximate surface. Each low-pressure turbine weighs 430 tons, and the rotor has a diameter, bare, of 15 feet 9 inches. With blades in place, the diameter is 19 feet 3 inches.

MAURETANIA TURBINES: HIGH PRESSURE AT RIGHT; ASTERN IN CENTER; LOW PRESSURE AT LEFT.

We described the method of fixing the turbine blades in the *Lusitania.* In the *Mauretania* a different method has been followed. The Parsons method, as adopted on the *Lusitania,* is to

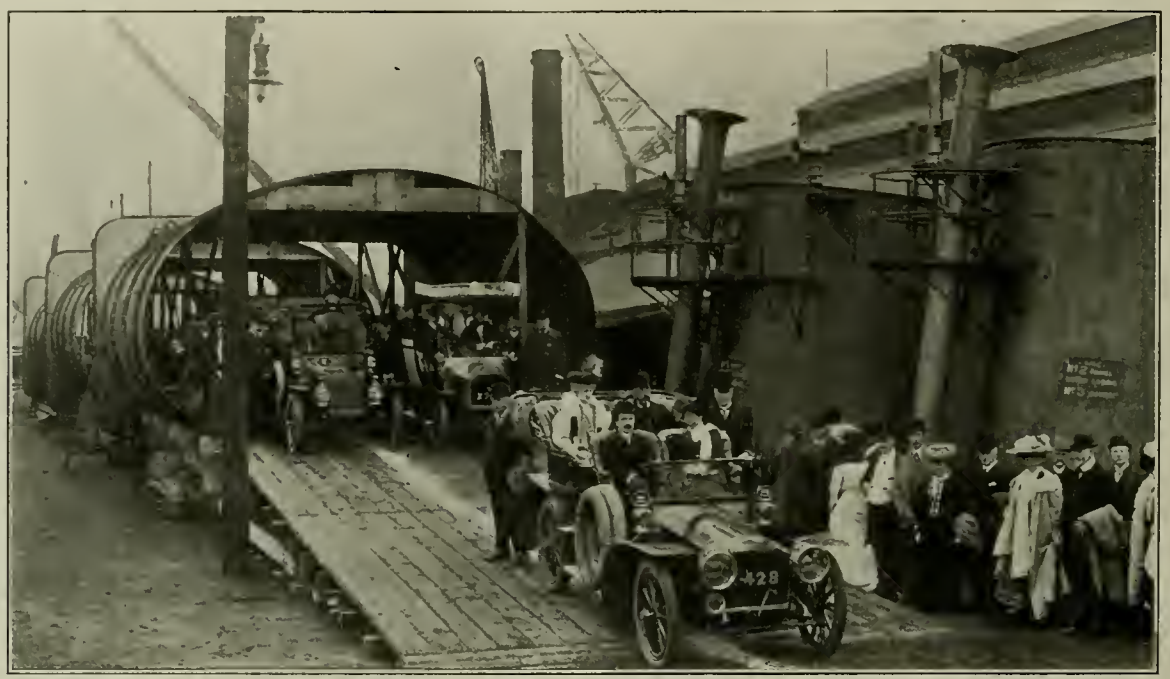
fix each blade separately into the grooves turned on the inside surface of the circular casing and on the outside of the round rotor. Each blade is separately wedged in position by a calking piece. In the *Mauretania* engines the blades were fitted into a curved plate, formed so that a series of ten plates constituted a complete ring for either the casing or the rotor; the blades are wedged into the plate, and the ten segments making up the complete ring are in turn wedged into the groove formed in the casing or rotor. Before being placed in the casing or rotor the blades on the plates are bound and laced together at the upper end. A binding strip is fitted into indents formed on the edge of the blades, and around this and the blades there is laced a wire to secure them together, the whole being soldered. The blades in the *Mauretania's* turbines increase in length from 2½ inches, where the steam is at highest pressure, to 23 inches, where it is at lowest pressure, the expanding steam requiring an increased length of blade to effectually rotate the blades on the rotor. The details required for the adjustment of the turbines to insure the most efficient minimum clearance between the blades and the adjacent surfaces correspond with those adopted on the *Lusitania*.



STERN VIEW OF THE MAURETANIA SHORTLY BEFORE LAUNCHING, SHOWING THREE OF THE FOUR PROPELLERS.

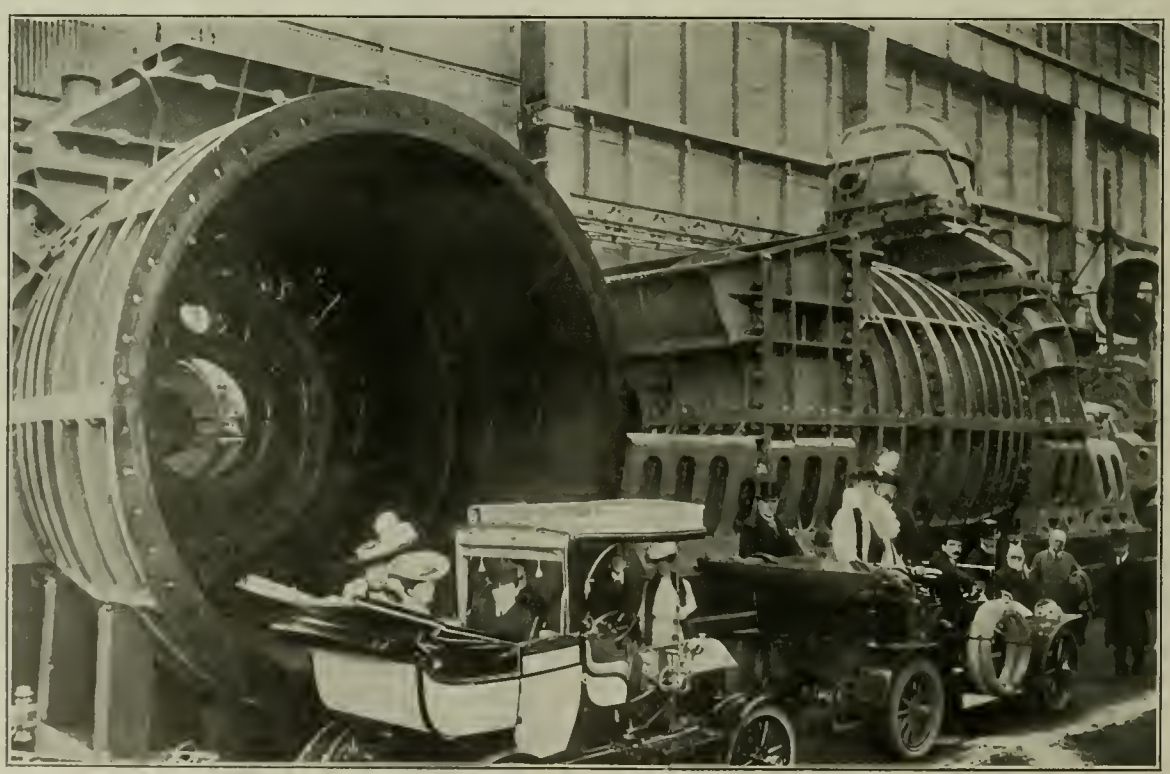
The auxiliary machinery has been supplied mainly by Scotch firms. Messrs. G. and J. Weir, Limited, Glasgow, supply the feed, air and other pumps, some of them being of immense size. They are fitting in the *Mauretania* thirty-seven pumps, for a variety of duties, also feed heaters. Messrs. Howden & Son have made the forced-draft gear. The windlass and capstan gear is by

Messrs. Napier Brothers, Glasgow, and is of massive proportions. The steering gear, with the engine on the tiller head, is by Messrs. Brown Brothers, of Edinburgh. Many of the heavy castings were made in the Glasgow district.



MOTOR CARS PASSING TWO ABREAST THROUGH A SECTION OF ONE OF THE FUNNELS.

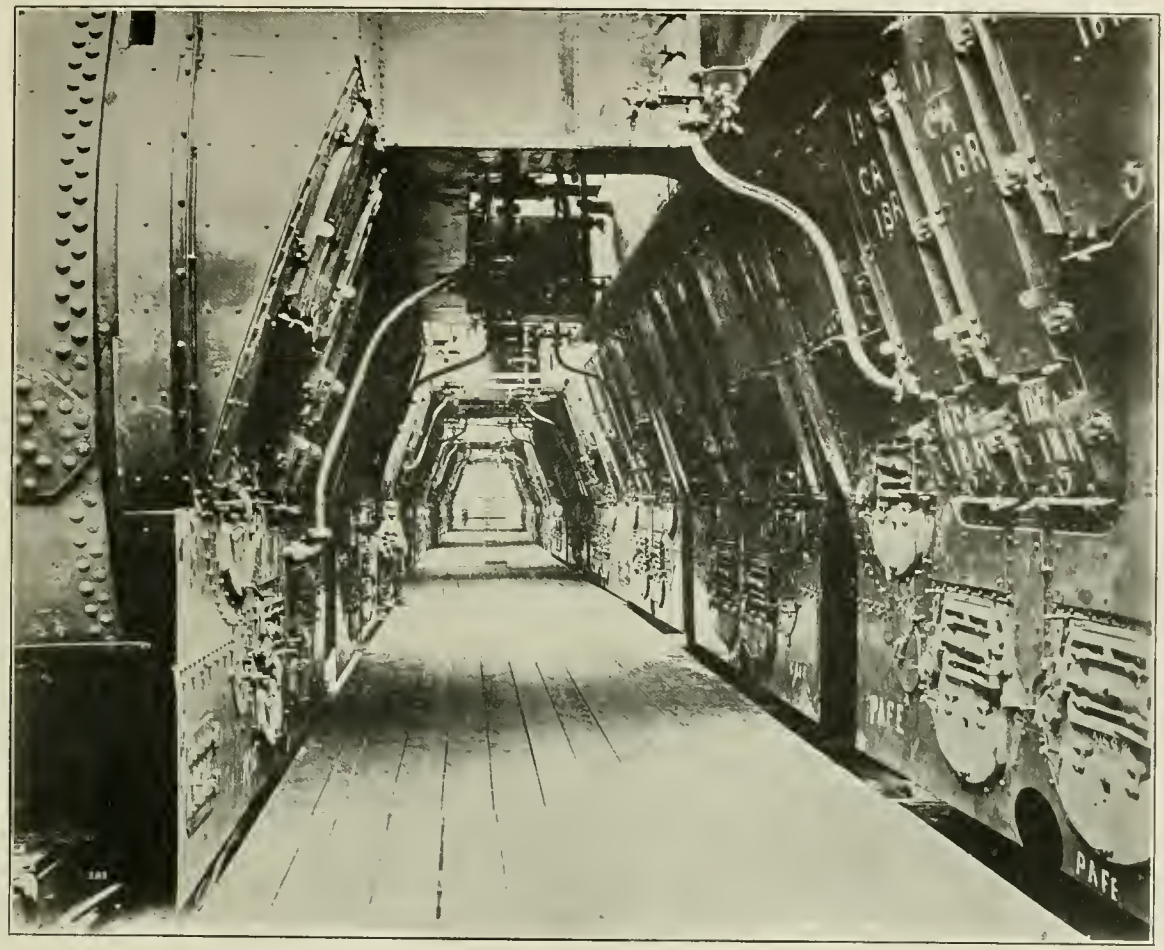
The boilers of the *Mauretania* are twenty-five in number. Two are single-ended, while the others are double-ended with four furnaces at each end. The steam pressure is 200 pounds to the square inch. The boilers are to be worked under Howden's system of heated draft, and the fans will be operated by electric motors. The boilers are arranged in four groups, and for each group there is a funnel, elliptical in shape and 22 feet in diameter. The tops of the funnels are 150 feet above the level of the keel. There are 4,000 square feet of grate area and 160,000 square feet of heating surface in the boilers, to develop the 68,000 to 70,000 horsepower required to attain a trial speed of 25¼ knots, and the 24¾ knots guaranteed speed on the Atlantic. This speed is a quarter of a knot in excess of that guaranteed by the Cunard Company under their agreement with the British government.



LOW PRESSURE CASINGS FOR MAURETANIA TURBINES, SHOWING EXHAUST NOZZLES.

The builders of the *Mauretania*—Messrs. Swan, Hunter and Wigham-Richardson, Limited, Wallsend-on-Tyne, are an amalgamation of Messrs. C. S. Swan and Hunter, Limited (dating

from 1872) and Messrs. Wigham-Richardson and Co., Limited (founded in 1860) with the Tyne Pontoons and Dry Docks Company, Limited. The works cover an area of seventy acres, and



PART OF THE BATTERY OF SCOTCH BOILERS SET UP IN SHOP. NOTE THE MAN AT LEFT.

have a river frontage of 4,000 feet. The berth on which the *Mauretania* was built is covered in, 740 feet long, with a width inside of 100 feet, and a height of 140 feet. Under the roof there are a large number of electric traveling cranes.

The turbine machinery has been built by the Wallsend Slipway and Engineering Company, Limited, a concern founded by a combination of shipbuilders to provide the machinery for the vessels constructed at their works. It is equipped with a slipway and a repairing dry dock, and some years ago the directors of the Wallsend establishment secured as manager Mr. Andrew Laing, long connected with the Fairfield Engineering Works, Glasgow. Immense engine and boiler shops were thereafter constructed by Sir William Arrol and Co., Glasgow, without interfering with engineering operations. The output of the concern now averages about 70,000 horsepower per annum, and three large marine boilers per fortnight. Naval machinery is constructed, as well as the best mercantile engines.

The Engineering and Machinery Exhibition.

From September 15 to October 17 an exhibition was held at Olympia, London, England, covering in general engineering and machinery of all descriptions. The President of the exhibition was Sir William H. White, late Director of Naval Construction of the British Navy, and other marine men noted among the patrons included: Sir Philip Watts, the present Director of Naval Construction; Sir Edward J. Reed, a former Director of Naval Construction; Sir John I. Thornycroft, Vice-Admiral Sir J. Durston, R. N.; Hon. C. A. Parsons, past President of the Institute of Marine Engineers; Lord Pirrie, Chairman of the Harland & Wolff Company; Sir Marcus Samuel, President of the Institute of Marine Engineers; and John Inglis the past President of the Institute of Marine Engineers.

Progress of Naval Vessels.

The Bureau of Construction and Repair, Navy Department, reports under date of September 11, 1906, the following percentage of completion of vessels building for the United States Navy:

			Aug. 1	Sept. 1
BATTLESHIPS.				
Nebraska	19 knots.	Morgan Brothers Co.	96.	96.38
Georgia	19 "	Bath Iron Works	98.43	99.6
Connecticut	18 "	Navy Yard, New York, N. Y.	97.6	99.08
Vermont	18 "	Fore River Shipbuilding Co.	90.5	92.7
Kansas	18 "	New York Shipbuilding Co.	85.8	87.
Minnesota	18 "	Newport News Co.	93.68	95.
Mississippi	17 "	Wm. Cramp & Sons	60.83	62.18
Idaho	17 "	Wm. Cramp & Sons	59.	60.29
New Hampshire	18 "	New York Shipbuilding Co.	50.3	51.8
ARMORED CRUISERS.				
California	22 knots.	Union Iron Works	94.6	95.
South Dakota	22 "	Union Iron Works	92.4	93.
North Carolina	22 "	Newport News Co.	53.87	57.18
Montana	22 "	Newport News Co.	47.66	51.03
SEMI-ARMORED CRUISERS.				
St. Louis	22 knots.	Neafie & Levy Co.	99.22	100.
Milwaukee	22 "	Union Iron Works	97.9	98.5
SCOUT CRUISERS.				
Chester	24 knots.	Bath Iron Works	40.8	44.97
Birmingham	24 "	Fore River Shipbuilding Co.	41.8	44.9
Salem	24 "	Fore River Shipbuilding Co.	42.6	45.
SUBMARINE TORPEDO BOATS.				
Cuttlefish		Fore River Shipbuilding Co.	81.7	84.9
Viper		Fore River Shipbuilding Co.	69.3	73.
Tarantula		Fore River Shipbuilding Co.	81.3	85.9
Octopus		Fore River Shipbuilding Co.	65.1	69.9

TRIAL OF THE BATTLESHIP NEBRASKA.

The standardization runs of the *Nebraska* took place July 16, 1906, over the measured mile course of Vashon Island, Puget Sound, beginning at nine o'clock in the morning and ending at twelve-forty. The weather was overcast and misty, with a smooth sea and a light breeze from the south.

The draft was measured both before and after the trial, and was found to be as follows:

	Before	After.
Forward	23 ft. 10⅝ ins.	23 ft. 6⅝ ins.
Aft	24 ft. 0⅝ ins.	23 ft. 10⅞ ins.
Mean	23 ft. 11⅝ ins.	23 ft. 8¾ ins.
Corresponding displacement...	14,985	14,815
Mean displacement during trial	14,900	

The results are given in the accompanying table and curve and show a maximum speed of nearly 20 knots. These curves have been plotted separately for the runs with and against the tide, the curve of true speed being midway between the other two. From this latter it was deduced that a mean of 119.85 revolutions per minute were required for the contract speed of 19 knots.

Number and direction of run	Elapsed times observed.	Mean revolutions per minute.	Speed in knots.
1—N	3—07.8	121.710	19.169
2—S	3—05.15	122.639	19.444
3—N	3—08.83	124.078	19.063
4—S	3—04.35	119.389	19.528
5—N	3—12.95	125.372	18.658
6—S	3—00.4	124.296	19.956
7—N	3—19.63	115.729	18.033
8—S	3—03.8	119.975	19.587
9—N	3—22.3	111.228	17.795
10—S	3—29.0	98.849	17.225
11—N	3—34.1	104.060	16.815
12—S	3—28.8	100.157	17.241
13—N	3—51.6	92.563	15.544

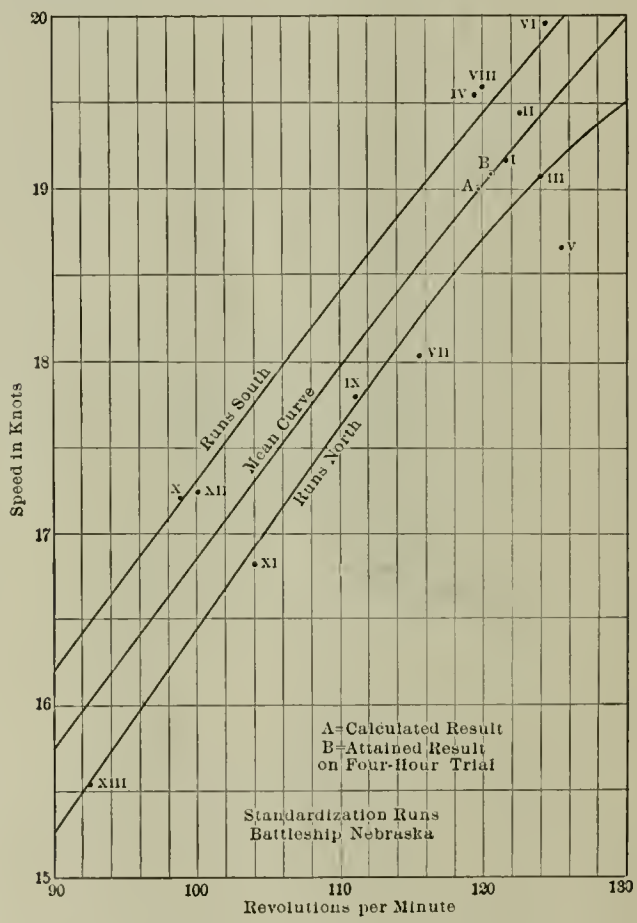
On July 17 the four-hour full speed trial was run, the draft at the beginning being, forward, 24 feet 1¼ inches; aft, 23 feet 9¾ inches; mean, 23 feet 11½ inches; with a corresponding displacement of 14,975 tons. As the vessel made a straightaway run, it was not feasible to obtain the draft at the end of the trial, but it was estimated that at the middle of the trial the draft was 23 feet 9½ inches, corresponding with a displacement of 14,865 tons.

The trial, which began at 8.29 a. m., was run in a smooth sea with light breezes from the south, the ship steering northwest by west. The data for this run are included in the table and log herewith.

Hour of day. h. m.	Mean revolutions per minute. Starboard engine.	Port engine.	Both engines.	Corresponding speed by revolutions.
A. M.				
8—29	(Beginning of run).			
8—44	121.5	119.6	120.53	19.070
8—59	122.2	119.0	120.56	19.071
9—14	122.8	120.8	121.78	19.181
9—29	122.9	119.9	121.41	19.140
9—44	123.6	121.6	122.60	19.257
9—59	123.0	120.	121.50	19.160
10—14	122.1	119.2	120.68	19.080
10—29	123.4	117.8	120.60	19.072
10—44	120.7	116.9	118.81	18.905
10—59	120.8	116.8	118.81	18.904
11—14	121.6	116.6	119.07	18.930
11—29	123.0	119.4	121.87	19.190
11—44	122.6	118.9	120.72	19.085
11—59	121.7	118.1	119.9	19.012
P. M.				
12—14	121.7	118.1	119.9	19.012
12—29	121.5	118.0	119.72	18.990

After completing the 4-hours' full-power trial, and while the vessel was still under forced draft, the steering gear was tested in the following manner: The helm was put hard-a-port (35 degrees) in 10.4 seconds; the time to swing her through 360 degrees with full helm was 3 minutes 40 seconds. The helm was then shifted from hard-a-port to hard-a-starboard in 16.8 seconds by the bridge indicator. The helm was then put amidships in 8.4 seconds. The maximum heel was 3 degrees, and the estimated diameter of the turning circle was 350 yards.

After completing the above tests of the steering gear, the helm was put amidships and after the vessel had gathered full headway of her course, the steam reversing gear of the main engines was reversed, the engines being started astern, and after they began to work astern at full speed, they were brought to full speed ahead.



REVOLUTION—SPEED CURVE FROM STANDARDIZATION RUNS.

After the fires had been reduced sufficiently to keep the steam pressure under control, the helm being amidships, the engines were reversed; and when making 60 revolutions per minute astern, the vessel was allowed to gather sternboard for two minutes; the helm was then put 15 degrees starboard, then 25 degrees port, then 30 degrees starboard, then 35 degrees port, then 35 degrees starboard, and allowed to remain at each of these angles for two minutes. The helm was then put amidships. During these tests the general operation of the steering gear was satisfactory.

The weight of machinery, including water in the boilers, condensers, etc., is shown by the report of the inspector of machinery at the contractors' works to be 1,681 tons.

The working of the machinery, both main and auxiliary, and its performance during the trials, was satisfactory except the priming of boilers caused by leaky tubes in main condensers. The boilers steamed freely and worked otherwise in a satisfactory manner throughout the trials. A careful observation and inspection

THE BATTLESHIP NEBRASKA, BUILT BY THE MORAN BROTHERS COMPANY, MAKING 19.51 KNOTS ON TRIAL TRIP.
(Copyright, W. P. Romans, 1906.)

of the various parts of the machinery during and after the trial showed the engines, boilers, and appurtenances to be in excellent condition.

The following is a summary of the observations recorded in the log during the four-hours' trial:

	Starboard.	Port.
Average revolutions per minute, four hours.	122.19	118.78
Mean revolutions per minute, both engines.	120.49	
Maximum steam pressure at boilers, in pounds	285.3	
Average steam pressure at boilers, in pounds.	271.3	
Maximum steam pressure at engines, in lbs.		
H. P. steam chest	257.	251.
Average steam pressure at engine	250.	238.
Maximum air pressure in fireroom	2.03	
Average air pressure in fireroom	1.55	
Maximum vacuum, each engine	25.	25.5
Average vacuum, each engine	19.5	25.2
Collective I.H.P. of all main engines	20,946.8	
Collective, main engine, air, circulating, feed, and hotwell pumps	21,282.8	
Collective, main, and all auxiliary engines in operation during trial	21,910.6	
Kind and quality of coal used on trial, Cardiff, coarse screened	excellent.	
Average pounds of coal used per hour during trial	61,991.	
Pounds of coal per hour used per horsepower by main and all auxiliary engines in operation during trial	2.83	
Speed of ship in knots	19.06	
Slip of propellers in percent of their own speed	17.023	14.453

A NEW ZEALAND MEAT-CARRYING STEAMER.

BY BENJAMIN TAYLOR.

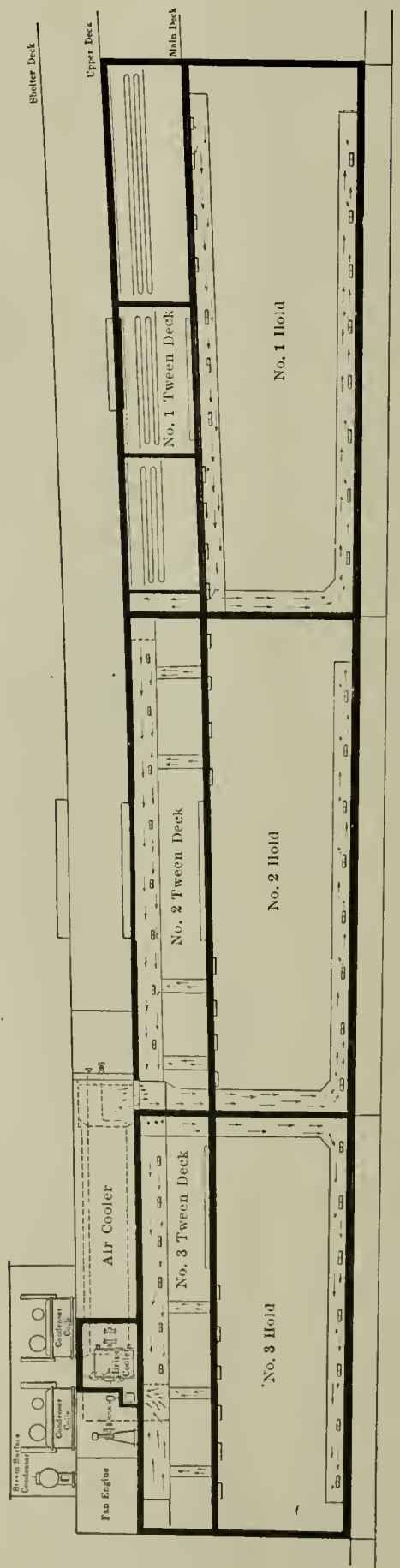
The twin screw steamer *Orari*, built by William Denny & Brothers, Dumbarton, for the New Zealand Shipping Company, is in many respects a notable and interesting vessel. Her principal dimensions are; length, 460 feet; breadth, molded, 60 feet, depth, 34 feet.

She is primarily intended for the New Zealand Shipping Company's extensive frozen meat trade from New Zealand to Great Britain, and the entire fore end of the ship is insulated in the holds and lower 'tween decks. One of the 'tween decks is divided into sections and refrigerated by brine pipes, which enables variations of temperature to be obtained suitable to the various classes of perishable cargo. The remainder of the cargo spaces are cooled by means of air driven through coil rooms, which are kept at a low temperature by the expansion of compressed ammonia.

The *Orari* has five hatchways, each of which is fitted with powerful cargo gear, with great outreach over ship's side. The stretch which the derricks possess permits cargo to be discharged direct into trucks without intermediate handling—an economy appreciated by consignees. There is also a large steel derrick at No. 2 hatch, for heavy lifts to be handled without shifting the vessel up to shore cranes.

Although not intended primarily for passenger service, the vessel has a few roomy and well-ventilated cabins provided for passengers. This accommodation, and that for the officers, is situated under the bridge deck. Owing to her great freeboard, the vessel is fitted with two flying bridges, one above the other, from the uppermost of which the sea can be seen close up to the bow. The steering is controlled from either bridge as desired. The vessel is fitted throughout with electric light, the installation being by the builders.

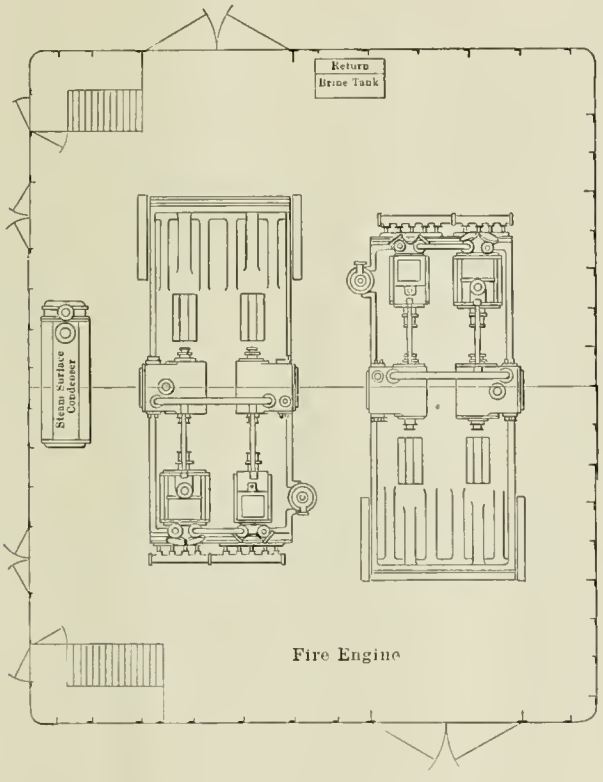
The propelling machinery consists of two sets of triple expansion engines, having cylinders 24½, 41¼ and 69 inches in diameter, with a stroke of 4 feet. The high and intermediate-pressure



LONGITUDINAL SECTION SHOWING THE AIR COOLED HOLDS AND 'TWEEN DECKS, AND THE BRINE COOLED NO. 1 'TWEEN DECK, OF STEAMSHIP ORARI.

cylinders are fitted with piston valves, the low-pressure being fitted with the usual multiple ported flat valve, with Joy's balance piston. In addition to the ordinary lubricating arrangement, fitted as a stand-by, the Axiom system is installed. The pistons are of steel, cast of cone shape to give the necessary strength. The piston rods are of forged mild steel and the glands, which are fitted with metallic packing, have rack and pinion gear for uniform adjustment. The connecting rods are of ingot steel, and, like the piston rods, are interchangeable throughout.

The valve motion is of the Stephenson type, with very large wearing surfaces. The reversing gear is of the all-round type, the reversing engine being itself reversible. The crank shafts are built of best ingot steel in three pieces, the material standing not only the Board of Trade and British Corporation tests, but also a series of special fatigue tests. The crank shafts also are interchangeable throughout. The bedplates are of strong cast iron, the main bearing bushes being fitted with plastic white metal.



PLAN OF REFRIGERATORING ENGINE ROOM.

The air pumps, which are worked by levers off the intermediate pressure cylinder, are of the Edwards type, with brass chambers, buckets, valves and valve seats. The circulating pumps are of the independent centrifugal type, one fitted to each condenser, but so arranged that each pump may serve both condensers if desired.

The boiler feed arrangement consists of two feed pumps on each engine, discharging into a separate tank draining to float tank, or direct to boilers as may be desired. When the former alternative is being employed two independently driven feed pumps are used, each of which can draw from float tank, condenser, or reserve feed tank, and discharge to the boilers, or circulate the water in the boilers when steam is being raised. These pumps are also available for pumping out the boilers when required.

The condensers are built of plate steel, with brass tubes and tube plates, having large cooling surface. The auxiliary condenser is capable of dealing with the exhaust from all deck and auxiliary machinery when the vessel is in port, and two large evaporators are fitted in the engine room for making up loss of feed.

The propellers have bosses of cast iron, with four adjustable bronze blades.

There are five cylindrical boilers working under forced draught on the Howden principle, each boiler having three Morison suspension type furnaces. The uptakes are led into a double-cased funnel, which has been specially arranged to suit the limitations imposed by the Manchester Ship Canal. Owing to the great length of the voyages in the New Zealand trade, the vessel has a very complete outfit of spare gear, tools and engine room outfit.

The refrigerating plant is supplied by the Haslam Foundry and Engineering Company, Limited, of Derby. It consists of two horizontal compound ammonia compression refrigerating machines, each driven by compound steam engine, combined on a massive cast iron bedplate, mounted on steel box containing the condenser coils, these being placed in a spacious engine room on the shelter deck, with a Haslam steam surface condenser supported on A-frames, with direct steam driven air and feed pump.

Each refrigerating machine is capable of performing the whole of the work of cooling the holds and 'tween decks with the air-blast system for the carriage of frozen mutton. No. 1 'tween deck is arranged with brine piping for the carriage of either chilled meat or dairy produce, as desired.

The air ducts and trunks are arranged so that the blast can be reversed in case of need. The brine coolers are fitted in the upper deck below the refrigerating engine-room in an insulated chamber, and are arranged to work at two distinct temperatures. Vertical duplex brine pumps are fitted, each capable of doing the whole of the work, and the water circulating pump for ammonia and steam condensers is placed in the main engine room.

The accompanying profile drawings show the several insulated holds and 'tween decks in relation to the air blast batteries, and brine room and refrigerating engine room on shelter deck. We also produce a plan showing the arrangement of the refrigerating machines, steam condenser, and return brine tank.

Shipping Losses, First Quarter of 1906.

Lloyd's Register reports the loss between January 1 and March 31, 1906, of 185 vessels of an aggregate of 163,519 tons. Of this list, 177 vessels of 158,526 tons represent the losses sustained by the fourteen principal maritime nations, as separately listed in the return. Of this total, 75 vessels of 99,369 tons were propelled by steam and 102 vessels of 59,157 tons by sail. It will be noted that the average size of the steam-propelled vessels is 1,325 tons, as against an average of 1,576 tons for the steam vessels owned by the nations in question. The sailing vessels lost average 580 tons, against 584 tons for the total. The average size of all the vessels lost is 896 tons, as against 1,222 tons for the total number of vessels owned. It should be noted that no vessels under 100 tons are included in the report.

Under the head of steam vessels, the number lost is 0.43 percent of the total number in service, while the tonnage lost was 0.36 percent. In the sailing vessels the number lost was 1.06 percent and the tonnage 1.05 percent. The total losses included 0.65 percent in number and 0.48 percent in tonnage. It will be noted from these figures and the comparison between the average sizes of vessels lost and the average of vessels owned, that the losses come in general from the small types of vessels. This, of course, is only what could have been expected, because the larger the vessel the better able she is usually of weathering conditions which would destroy smaller craft. It is both the losses of the smaller type of vessel, and the rapidly increasing size of the average new vessel built, that are accountable for the increasing average size of ships in service in the various mercantile fleets.

Propeller Performance of the Indiana.

BY LIEUT. H. C. DINGER, U. S. N.

The United States battleship *Indiana*, at her last docking, had her propeller blades changed. The propellers are three bladed and are arranged to turn outboard in going ahead.

The old blades gave the following dimensions:

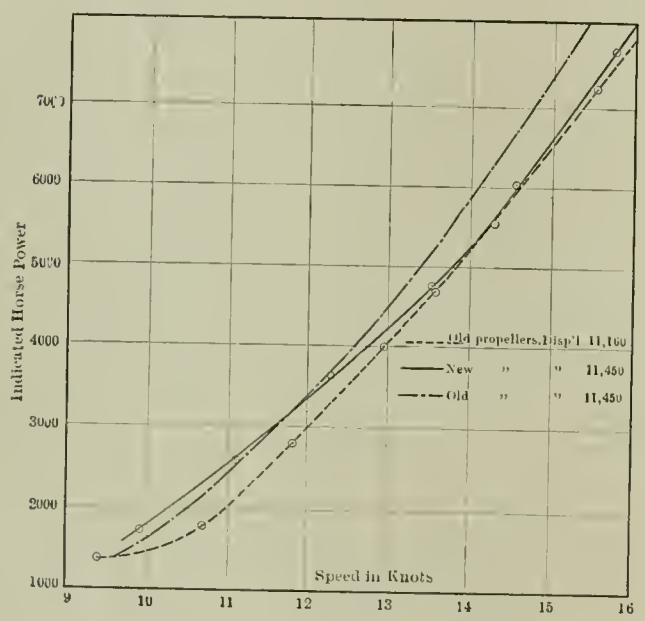
Diameter ..... 15 feet 6 inches
Helicoidal area for each propeller .....53.9 square feet
Pitch set at .....16 feet

The new blades gave the following:

Diameter ..... 15 feet 6 inches
Helicoidal area of each propeller.....75.6 square feet
Projected area of each propeller.....64.3 square feet
Pitch set at .....16 feet 3 inches

The vessel was standardized with the old blades February 26, 1906, at Guantanamo. The results were plotted in curves of revs -speed, revs-I. H. P. and speed-slip. From these curves the data in the table are taken. The displacement was 11,160 tons; draft, forward, 25 feet 1 inch, aft, 26 feet 7 inches, mean, 25 feet 10 inches.

The vessel was standardized with the new blades July 17, 1906,



SPEED—POWER CURVES, OLD AND NEW PROPELLERS.

at Provincetown. The displacement was 11,450 tons; draft, forward, 25 feet 8 inches, aft, 27 feet 2 inches, mean, 26 feet 5 inches. The results are likewise plotted in curves of revs-speed, revs-I. H. P. and speed-slip. From these curves the data in the table are taken.

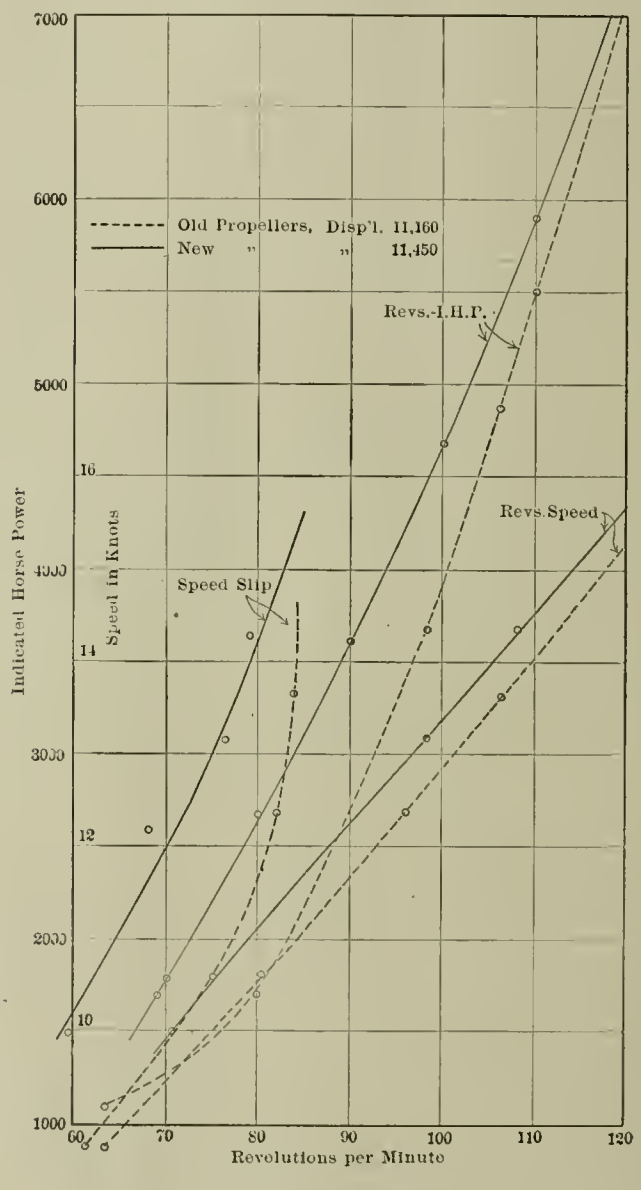
The highest speed actually run on the standardization was 13.6 knots for the old blades, and 14.43 for the new. The results for the high speeds in the table are taken from the extension of the curves beyond the actual points obtained.

Revolutions	Horsepower		Speed, Knots		Slip, Percent	
	Old	New	Old	New	Old	New
70	1,300	1,550	9.4	9.8	14.2	12.
80	1,700	2 700	10.7	11.1	16.3	12.5
90	2,800	3 600	11.8	12.3	17.6	15.2
100	4 000	4 700	12.9	13.5	18.3	16.7
110	5,500	6 000	14.2	14.5	18.5	17.9
120	7 250	7 400	15.5	15.75	19.	19.5

From these two tables were plotted the accompanying speed—I. H. P. curves. They would show the comparative efficiency of the two sets of blades.

The displacement was slightly less when the old blades were standardized, namely, the difference between 11,450 tons and 11,160 tons. The time out of dock was about the same. If the difference of displacement is taken into account on the basis that power varies as $\left(\frac{D}{d}\right)^{\frac{2}{3}}$ then the third curve will be obtained. The vessel was higher forward when the new screws were tried. This may have had some effect in giving slightly better results.

The changes made consist in increasing the area and the pitch. This has resulted in a general decrease in slip, a falling off in



SPEED—REVOLUTIONS AND POWER—REVOLUTIONS CURVES.

efficiency at slow speeds, and an increase in efficiency at the higher speeds. This is similar to the results obtained by changing the propellers of the *Charleston*.

It is believed that in this case the area was increased somewhat too much, and that the pitch should not have been increased beyond 16 feet. While the old blades were quite deficient in area, the new ones may be considered to have somewhat too much area and pitch, which produce greater frictional losses. The new blades have made a considerable change in the starting and stopping of the vessel, which can now be stopped in 360 yards.

An Interesting Old Patent.

A patent issued in 1788 by King George the Third, of England, dealing with the application of the steam engine to the propulsion of vessels and of vehicles, reads as follows:

To all to Whom These Presents Shall Come, we, Robert Fourness and James Ashworth, of Elland, in the Parish of Halifax and County of York, Gentlemen, send greeting.

Whereas, His Most Excellent Majesty King George the Third did, by his Letters Patent, bearing date the fourth day of March in the——year of his reign give and grant unto us the said Robert Fourness and James Ashworth, during the term of years therein expressed, should and lawfully might use, exercise, and vend, within England, Wales, and the Town of Berwick-upon-Tweed, our Invention of *"A New Invented Machine for Working, Towing, Expediting, and Facilitating the Voyage of Ships, Sloops, Barges, and other Vessels upon the Water, Whereby the Conveyance of Goods will be Rendered more certain as to the Time upon the Water;"* in which said Letters Patent there is contained a proviso obliging us, the said Robert Fourness and James Ashworth, under our hands and seals, to cause a particular description of the nature of our said Invention, and how the same is to be performed, to be enrolled in His Majesty's High Court of Chancery within one calendar month next after the date of the said recited Letters Patent, as in and by the same, relation being thereto respectively had, more fully and at large appear.

Now Know Ye, that in compliance with the said proviso, we, the said Robert Fourness and James Ashworth, do hereby declare that our said invention of a new machine for expediting and facilitating the voyage of ships, sloops, barges, and all other vessels upon the water, is described in manner following, the steam or fire engine being the principal of power:

Fig. 1, the ground plan of the steam or fire engine; *A*, the grate on which the fire is lighted; *B,B*, the shape of the boiler bottom; *C,C*, the case in which the boiler stands; *D,D*, flew round the boiler for the flame to pass through; *E,E,E*, three steam cylinders; *F,F,F*, three flanges by which the cylinders are extended to their bottoms. N. B.—A single cylinder or any number of cylinders may be used in place of the three here specified. *G,G*, two regulators, the one for steam, the other for the injection water; *H,H,H*, three force pumps; *I,I*, a box into which the steam is received from the boiler, and in which is placed a metal plate with three holes in, through which the steam is admitted into each cylinder through a pipe leading from each hole, and a metal plate which regularly revolves upon the face of the plate *I,I*, in the box, by a spindle passing from the wheel *D* in Fig. 5, to regulate the admission of steam alternately into the cylinders; *P*, another plate, with three holes in, placed in the box which receives the injection water from the cistern, *P*, as described in Fig. 2, on which revolves by a spindle passing from the other wheel *D* in Fig. 5, in the same box, the plate *M* with two holes in as *N,N*, to regulate the injection of condensing water in the cylinders.

Fig. 2, *A,A,A*, six wheels fixed upon the spindles *C,C,C*, between which are fixed three round bearing studs, as *B,B,B*, situated as described by *B,B,B*, in Fig. 3. A crank in various forms may be applied for the same purpose as those six wheels *A,A,A*, are applied. *D*, a cog wheel fixed on the spindle *C,C,C*, which gives motion by the nut upon spindle *E* to the wheel *A* in Fig. 5, upon the bottom of the same spindle *E*. *F*, the crown of the boiler in which the steam is generated; *G,G*, the case in which the boiler stands; *H,H,H*, three steam cylinders; *I*, a force pump that raises water for injection into cistern *P*; *K*, a force pump for the use of keeping ship or vessel dry; *L*, another force pump by which a sufficient quantity of hot water is raised to replenish the boiler through the pipe *M*; *N*, the steam pipe; *P*, the cistern into which the injection water is forced; *Q*, the rod of the piston of the injection cistern, to which is added a spiral spring which gives force to the injection; *R,R*, two winches on the lower end of which are fixed two valves or cocks by which the steam or injection water are entirely shut off from the cylinders at pleasure; *S,S*, the two boxes in which the regulating plates described by *R* and *M*, in Fig. 1, work; *T*, a valve to let out the superfluous water from the force pump *I*; *U*, the chimney of the furnace.

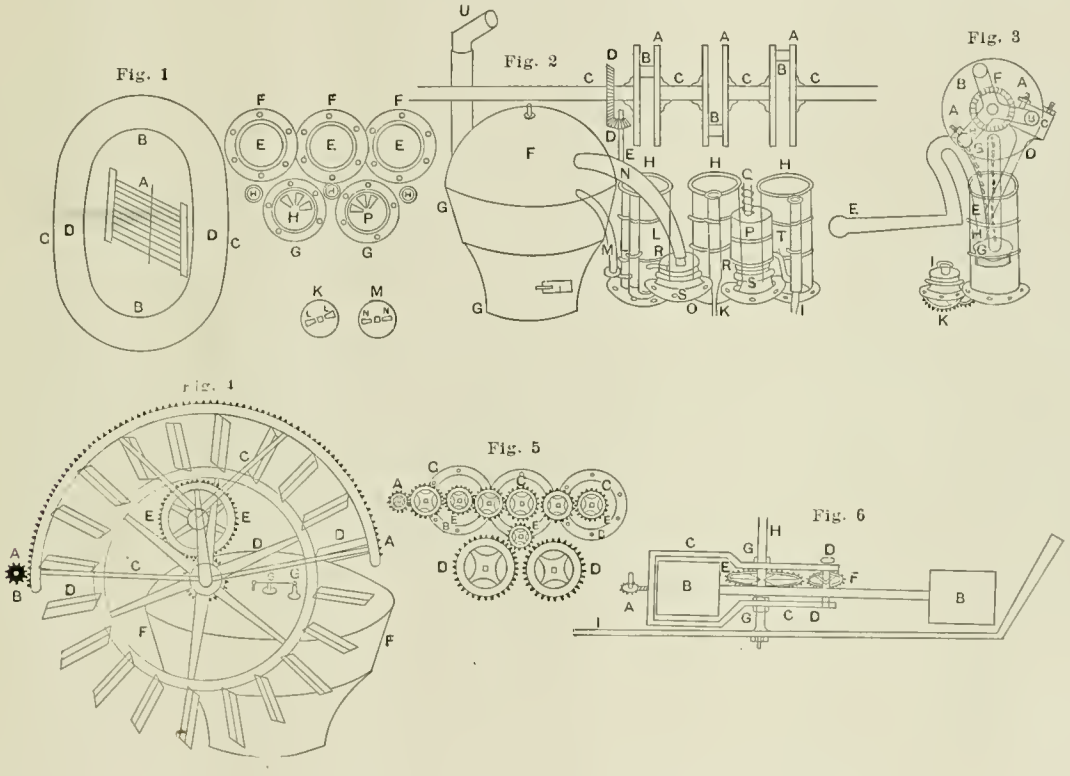
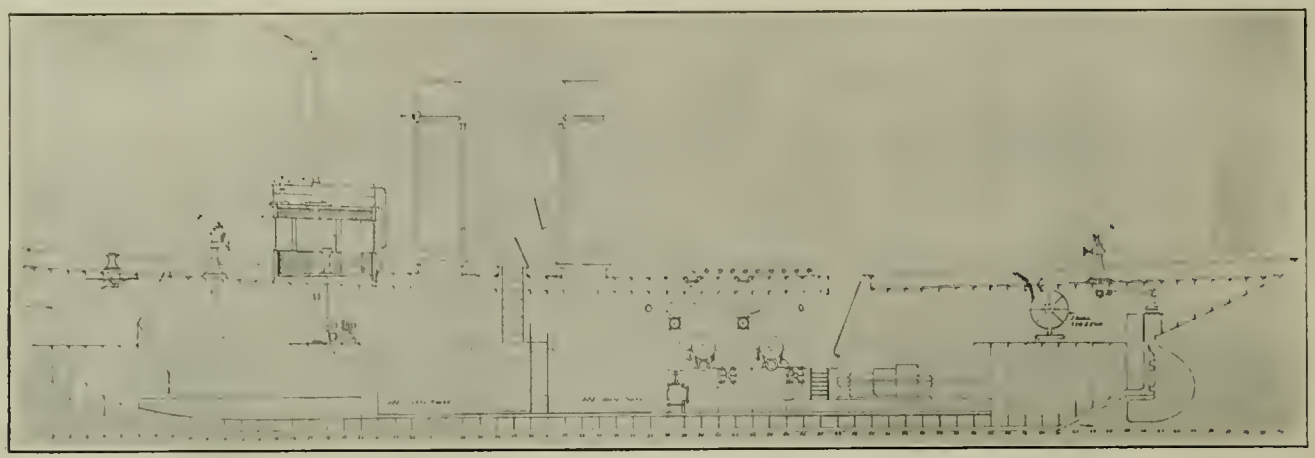


DIAGRAM OF A MARINE STEAM BOILER AND ENGINE, PATENTED IN ENGLAND IN 1788.

Fig. 3, a side view of one cylinder and its apparatus; *A,A,* one of the wheels in which the studs *B,B,B,* in Fig. 2 are fixed; *B,B,B,* three studs to which the rods are connected, as described, by the rod *D,* and are connected by the coupling boxes *C,* which rod is joined to the beam *E,E,* at letter *H; F,* a cog-wheel as described by *D* in Fig. 2; *G,* the piston and rod, showing the chains by which the working beam and piston are connected; *I,* one of the boxes mentioned in Fig. 1, which contains

And Be It Remembered, that the said Robert Fourness and James Ashworth came into the Court of our said Lord the King in his Chancery, and acknowledged the Specification aforesaid, and every matter and thing therein contained and specified. And that the Specification aforesaid was duly stamped according to the tenor of the Statute in that case made and provided.

Inrolled the Second day of April, in the year last above mentioned. —*Power.*



INBOARD PROFILE OF REILLY TURBINE PROPELLED FIRE BOAT, WITH TURBINE DRIVEN CENTRIFUGAL PUMPS

the regulators; *K,* one of the wheels by which the regulators are actuated.

Fig. 4, a side view; *A,A,* a semi-circular rack and pinion by which the working or driving wheel *D,D,D,* is raised out of or lower'd into the water, as the burthen of the vessel may require; *E,E,* a cog-wheel fixed on the end of the spindle *C,C,C,* in Fig. 2, which gives action to the wheel *F* in Fig. 6, on whose spindle the working or driving wheel *D,D,D,* is fix'd; *F,F,* the boiler in which the steam is generated; *G,G,* a safety valve and weight fix'd in the top of the boiler.

Fig. 5, a flat section of the wheels used in the regulation of the steam and injection; *A,* a nut upon the bottom of the spindle *E,* in Fig. 2, which gives motion to all the other regulating wheels; *C,C,C,* six wheels of equal diameter; *D,D,* two wheels fixed on the bottom of the spindles of the regulating plates as described by *K,M,* in Fig. 1; *E,E,E,* three wheels fixed severally under the center of the bottoms of the cylinders, in the center of each of which wheels is fixed a hollow cock pin, which lets out of the cylinders the hot water, air, etc., after each stroke made by the piston. N.B.—Any other gear applicable to the steam engine may be used instead of the gear here specified.

Fig. 6, a flat section of the working or driving wheel on one side of the vessel, and its apparatus; the same sort of wheel, and apparatus to force it, being applied on the other side of the vessel also. *A,* a rack and pinion described by *A,A,* in Fig. 4. *B,B,* the floats of the working and driving wheel. N.B.—The working, driving, or rowing wheels may be made in various forms; one alone may be applied, or any plurality; oars also may be applied, in lieu of the working, driving, or rowing wheels. *C,C,* a frame in which the working, etc., wheels are fix'd and rides upon the axis of the spindle *D,D,* on which is fix'd the wheel *F,* which gives motion by the action of the wheel *E* fix'd upon the spindle *H,* as described by *C,C,C,* in Fig. 2; *G,G,* the two bearings on which the frame of the working wheel *B,B,* rests; *H,* the spindle described in Fig. 2, under *C,C,C,; I,I,* a rail intended for the safeguard of the working, driving, or rowing wheel or wheels.

In witness whereof, we, the said Robert Fourness and James Ashworth, have hereunto set our hands and seals, this Twenty-ninth day of March, One thousand seven hundred and eighty-eight.

Robt. Fourness (L. S.)
James Ashworth (L. S.)

Preliminary Designs for a Fire Boat.

The hull is to be of the flush deck type, the general design to be as shown. It shall be constructed of steel throughout; shall be made of ample strength to withstand ramming at full power into ice; and so shaped that it can be successfully maneuvered in ice as well as in open water. It shall have a speed of 18 knots; the five pumps shall be of sufficient capacity to discharge 8,000 gallons of water per minute, at a pressure of 200 pounds per square inch; it shall be lighted throughout by electricity, including an 18-inch search light projector.

The principal dimensions are:

Length over all	150 feet
Length between perpendiculars	132 feet
Breadth molded	25 feet
Depth molded	16 feet
Draft, normal	10 feet
Displacement, normal, about	450 tons

MACHINERY EQUIPMENT.

Propelling Engines.—The propelling machinery shall consist of two marine turbines, each driving an independent shaft and screw; the total horsepower shall be about 1,800.

Boilers.—The boiler plant to consist of two Babcock & Wilcox water tube boilers, of sufficient capacity to furnish steam for 2,000 horsepower, the steam pressure to be 200 pounds per square inch.

Fire Pumps.—The fire pump equipment to consist of four turbine driven centrifugal pumps, each pump to have a capacity of 2,000 gallons per minute at a pressure of 200 pounds per square inch, or a total capacity for the four pumps of 8,000 gallons per minute.

Fire Outfit.—To have one hose tower with a 3-inch nozzle, tower to be universal acting, to have a maximum hoist of 68 feet; two 4-inch monitor nozzles located as shown; twenty-four 3½-inch hose connections, arranged so as to be available for service on either side of the ship.

Quarters for Crew.—Bath and toilet rooms only to be supplied on board ship.

Deck Outfit.—To be complete, as required by the City Fire Department and the United States Inspectors of Steam Vessels.

Special Features.—A special feature of this design is in the

construction of the hull, which enables the hose connections to be used for service on either side of the ship. Another feature is the hose or water tower, with which arrangement a stream can be thrown into the hold of a vessel, or over the deck of a vessel into the hold of another vessel, or over or into a warehouse alongside of a wharf.

General Design.—The aim of the whole design has been to incorporate the most successful features and ideas of the various fire boats that have been built in this and other cities, and to incorporate such features as experience has proved to be desirable. Special stress has been laid on the arrangement of the fire and steam mains; for the first, so that a clear unobstructed deck may be had for the handling of hose and equipment; for the second, that an ample steam supply can be had at all times, so that the apparatus can be worked to its full capacity, without causing priming, etc., and that an ample supply of water can easily be fed to the pumps without causing water hammer, air pockets, or other features which are detrimental to the successful operation of the boat as a fire fighting apparatus. Ability is given to have vessel under headway within two minutes after alarm.

It is said that at no time, unless for extraordinary repairs to boilers or hull, would it be necessary to lay up longer than six hours for repairs to pumps or engines, and that the speed of 18 knots obtainable with this design would be impossible with the old type of reciprocating engines and pumps, displacements being equal.

Fire Pumps.—In the fire pumps a decided departure has been made from the usual duplex double acting reciprocating pumps. Instead of these it is proposed to install four centrifugal turbine driven pumps, for the following reasons. The turbine pumps deliver the water at constant pressure, this eliminates the forces of the hose pulsations (which are due to the reciprocating pumps) and enables the pipemen to handle with ease a line of hose that would be an impossibility with the old style of pump, again, the pumps turning with a uniform speed makes the requirement for steam uniform at the boilers, thus priming and the lifting of water at the boilers is eliminated.

The pumps consisting of four units, any two can be under repair, and still leave a good apparatus in commission; the turbines and pumps being light and of standard design, an extra steam and water wheel could easily be carried on board, and in case of breakage, repairs to any of the pumps could be made in a short time.

This design is by the James Reilly Repair and Supply Company, of New York.

It is reported that the British battleship *Dreadnought*, in a recent trial, made an average of 21.5 knots, the maximum being 22.25 knots. Horsepower, 28,000.

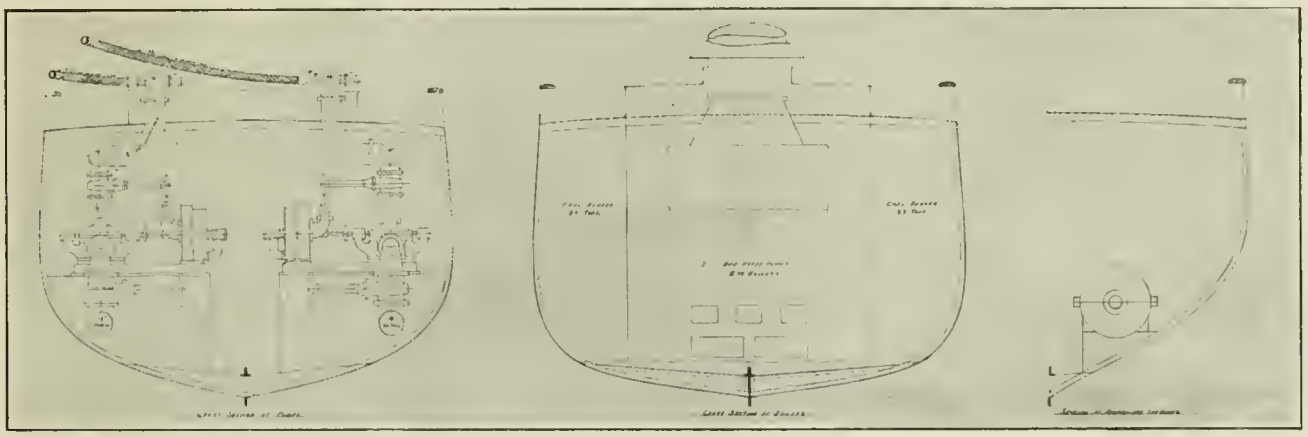
FLOATING DRY-DOCK CONSTRUCTION.*

By William T. Donnelly.

I have considered the subject under several general heads so as to give some comprehensive idea of it to those entirely unfamiliar with it, and then to go into the details of the construction of large floating docks, which will be of more interest to those already familiar or interested in the particular line of engineering. I shall first endeavor to give a general idea of what a floating dry dock is.

Fig. 1 shows a 10,000-ton floating dry dock with a large steamer upon it, the Fall River liner *Priscilla*, with which you are all probably familiar. A floating dry dock, as you will readily see, is a large floating structure, so large that it can not only float itself, but carry also the largest vessel for which it is designed. The steamer you see here is 440 feet long, 92 feet wide over the guards and has a draft of about 16 feet. The dock is 468 feet long, and is composed of five sections or separate floating parts, which are connected together and operated as one; these sections will be fully explained later.

The manner of getting this ship upon the dock was as follows: You will notice that on each side of the boat the dock has high, narrow sides which come above the water line of the boat, and



TRANSVERSE SECTIONS OF TURBINE PROPELLED FIRE BOAT, SHOWING LOCATION OF MACHINERY EQUIPMENT.

you will readily understand that these sides, which carry the machinery, could be above the water, while the central part of the dock was far enough below the surface to allow the steamer to float in between them. Much the larger part of this dock is now below the surface of the water and is in the form of a large hollow box connecting the two high sides. All the different divisions of the dock are provided with means for letting in water and for taking it out.

The operation of this dock is as follows:

When the steamer was approaching to be docked, the dry dock was about at the level that you now see it, but, of course, the space between the high sides was vacant and all that you would see would be a long line of keel blocks down the center (some of which you can now see in front of the boat); those on which the steamer was to rest had all been carefully arranged to correspond with the keel of the boat, and certain blocks on each side, known as bilge blocks, had also been arranged. About the time when the steamer first came in sight the dockmaster gave instructions to open the flood gates. As soon as this was done, the water commenced to flow into the dock from the outside and the dock commenced to sink, the water flowed over the deck, then covered the keel and bilge blocks until nothing was left above the water but a long narrow strip on either side. When the dock had settled until there was about a foot more water above the keel blocks than the draft of this steamer, the flood gates were closed and the dock floated quietly. Then word was

*Paper before the Brooklyn Engineers' Club.

signaled to the steamer, which in the meantime had come up, and, if under steam, she steamed in or was pushed in by a tug, or perhaps was pulled in by her windlass engine hauling on the line, which you can see reaching from her hawse hole to the mooring post on the pier. When the steamer had been carefully located directly above the keel blocks which had been arranged to carry her, the machinery for removing the water was operated, and just as the letting in of water caused the dock to descend, the removal caused the dock to ascend, at first slowly, until the long line of keel blocks gently touched the bottom of the steamer. When firmly grounded on these the bilge blocks were drawn. This means that a certain number of blocks which had been arranged to support the vessel under each bilge or side were pulled inward from each side of the dock towards the center until they touched the steamer, and acted both as side supports and props to keep the vessel upright as she rose out of the water. When this was accomplished, the machinery was operated more rapidly, and the dock and vessel, which now became like one structure, rose together out of the water. The time from the location of the steamer in the dock until she was raised entirely out of the water, as shown, was about 45 minutes.

FIG. 1.—10,000-TON BALANCED SECTIONAL FLOATING DRY-DOCK, TIETJEN & LANG DRY-DOCK CO., HOBOKEN, N. J.

I will next take up the historical side or the development of floating dry docks in the United States. The floating dry dock is generally considered to be an American invention, and this would seem to be probable from a patent issued to J. Adamson in 1816. This is one of the first patents issued by the United States, and was at a time when the patents were so few that the government had not discovered the necessity of giving each a number.

At this time a floating dock was a very simple structure. The idea originated from the wreck of an old hull laying on some sloping beach, which was used by cutting out the stern and making gates to close the opening, similar to those of a canal lock. When the gates were open and the water admitted, the structure rested upon the bottom, and at high tide the boat to be docked was floated in and located. As the tide receded the water left the dock, and when it was all out the gates were closed and its return was prevented. It can be seen at each side in the plan view that pumps were provided which were operated by hand. It is most probable that these were intended to take care of only the leakage. It is evident that this is not, strictly speaking, a floating dry dock, as it was evidently intended to rest on the bottom, but, as you will understand, at an extra high tide it must either fill over the sides or float, and at some time became the first floating dry dock, probably against the will rather than from the intent of the inventor. Old as this form of dock is and limited as is its use, there was within a few years one of precisely this construction in use in Weehawken Cove, Hoboken, for the dry docking and repairing of canal boats.

The germ of another line of thought has relation to the development of floating dry docks, and shows, as far as I am aware, the only recorded invention by a president of the United States, as this is a patent granted to Abraham Lincoln in 1849. From the "Life of Lincoln" we learn that about this time he made a trip on a flat boat down the Ohio and the Mississippi rivers, and it was undoubtedly his experience with sand bars and shoals on this trip that was the occasion of this invention, which is in the nature of additional buoyancy carried on each side of a boat to be used in water too shallow to float the vessel. The intention evidently was to lower the long hollow boxes which are on each side, into the water, and then to force them down into the water by means of ropes and framework. I am not aware that this invention ever came into use, and its inventor certainly had other and more weighty matters to think of in after years.

The first large floating dock which was built in this port is the oldest floating dry dock now in use, and can be seen at the Erie Basin, Brooklyn. As originally constructed, this dock had a gate at each end, which was intended to operate after the principle of the dock invented by Adamson, but when completed it was found impossible to use it in that way. The reasons which led to its failure I will explain later when I come to describe the operation of the various forms of floating docks. This was, at the time of its construction, between 1845 and 1850, a very large structure, and it remains to-day the largest single structure in wood that has been undertaken for a floating dock. It is 330 feet long by 100 feet wide. It is known as the old balanced or box dock.

When it was found impossible to handle a single large floating structure with a ship upon it, the development took an opposite turn, and a number of small floating structures were built, to be connected and used together, and this form of dock has been known as a "sectional floating dock." It is composed of a number of separate floating sections connected together on each side by locking logs, which are designed to permit a limited amount of motion between the sections, while keeping them in alignment, particularly while sinking. The flexibility or movement between the sections made it necessary to provide some flexible means of transmitting power from one section to the others, and for this

purpose a double universal joint, with a slip or extension joint between, was invented. This will be more fully explained later. This dock, while having many undesirable features, was found to be very practical, and large numbers of them were built. The dock here shown has four sections. They have been built with from three to seven sections, which, with a section of about 25 feet in length, gave a dock about 200 feet in length, allowing for a short distance between the sections and a prow or overhang at each end.

The next type to which I will call your attention is shown in Fig. 2. This is known as a Dodge-Burgess sectional floating dock, and was the subject of a joint patent to them under date of October 9, 1841. The general arrangement of this dock is a number of pontoons, ten, as here shown, arranged and connected together as in a sectional dock by a locking log, but in this dock the wings are absent, as you will see in the cross-section, and in their place there is only a framework, upon the top of which the machinery house is carried. This framework is attached to the central pontoon and raises and lowers with it.

At each side, in the cross-sectional view, directly below the machinery houses, you will see a ballast tank. This tank always remains at the surface of the water, and is for the purpose of controlling the equilibrium of the lifting pontoon while submerged. The pumping of this dock is by machinery carried upon the top of the framework, and the power is distributed along the top by a shaft with flexible couplings, in the same manner as previously described for the sectional dock.

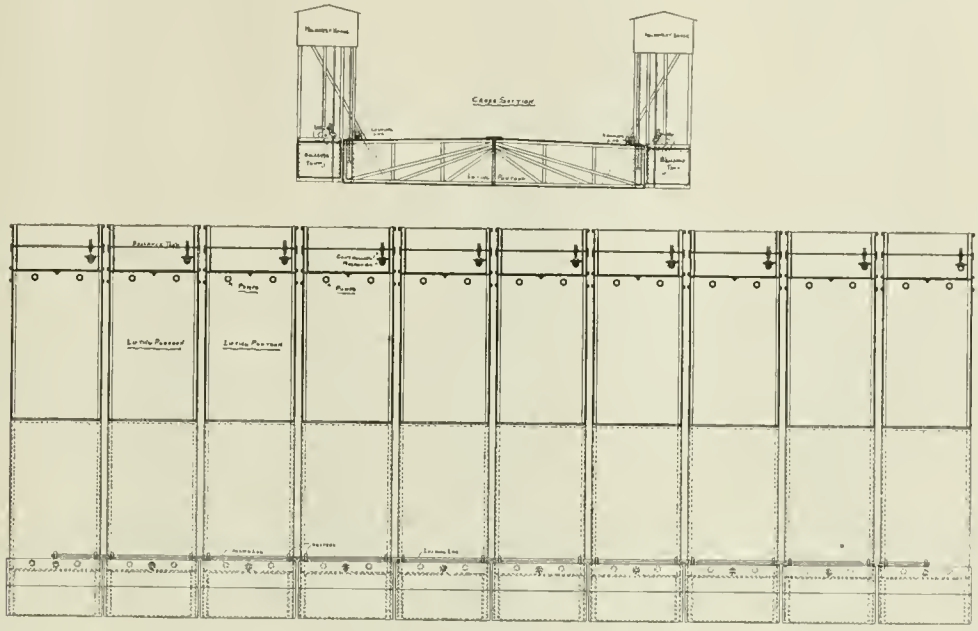


FIG. 2.—DODGE-BURGESS SECTIONAL DOCK.

This type of floating dock was the largest that had been built in this country up to a very recent date, and is probably the most familiar, as two of these docks were located upon the New York water front, near Catherine street ferry, for many years. The larger one was composed of eleven sections, each 30 feet long by 100 feet wide, it being understood that I speak of the length as 30 feet from the fact that this is the dimension which

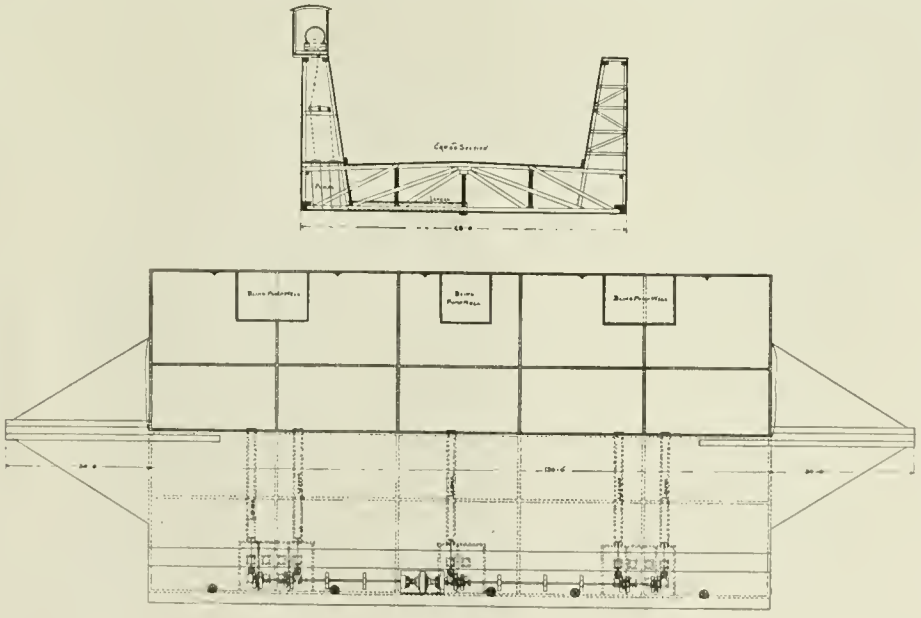


FIG. 3.—BOX DOCK.

forms a portion of the length of the dock when considered as a whole These sections, with the space allowed between them, made a dock about 350 feet long, having a lifting power of about 3,500 tons.

Fig. 3 shows the next development. This form is known as a box or balanced dock. As you will readily see, it was built in one piece, and, to overcome the difficulties occasioned by the flow of the water from one end of the interior to the other, the cross-bulkheads, which are water-tight, were added. These cross-bulkheads, four in number in this case, together with the center longitudinal bulkhead, divide the dock into ten independent water-tight compartments, and, by means of gates which control the flow of the water from all of these to the pumps, it is possible to control or balance the dock and ship.

The building of docks of this type commenced about the close of the civil war, and their construction continues at the present time; the small and moderate-sized are the most popular, and there are undoubtedly more of these docks, ranging in capacity from 500 to 3,000 tons, in the waters of the United States, than all other kinds taken together. This dock answers all the requirements up to a length approaching 300 feet. At about this length the proportion of length to depth is so great that it becomes impracticable to obtain sufficient longitudinal rigidity with wood as a structural material. A combination of wood and iron has been tried, but with very unsatisfactory results. The cost of a steel dock of this type is so much greater than one of wood, and its prospective cost of maintenance so much more, as to deter any attempt in that direction for commercial purposes up to the present time.

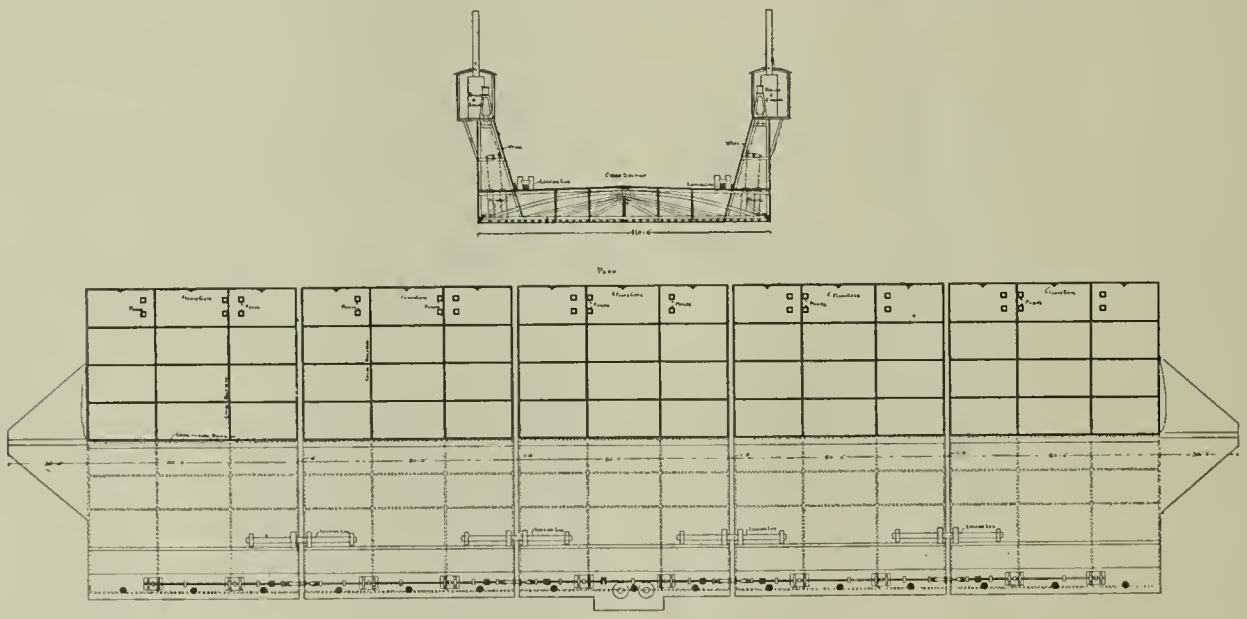


FIG. 4.—LANG'S BALANCED SECTIONAL DOCK.

I will now pass to the most recent development and largest type of floating dock for commercial purposes in use in this country. Fig. 4 shows a balanced sectional floating dry dock. Each of these sections, of which there are five, possess all the advantages of a box dock, that is to say, cross and longitudinal bulkheads and separate gates and independent means of admitting and removing water. Besides these, there are added all the advantages of the sectional dock, such as the freedom from internal longitudinal strains, and self-docking, which is a very important consideration in large docks.

The pumping machinery consists of a boiler and engine on each side of the dock. These operate a line shaft provided with flexible connections between the sections. This line shaft operates through intermediate gearing two pumps in each water-tight division of each section. As each section is divided into six compartments and there are five sections, there are sixty pumps. The dimensions of this dock are 468 feet long on keel blocks by 110 feet wide over all. The height of the wings is sufficient to take a draft of 21 feet over 3-foot keel blocks. The lifting capacity is 10,000 tons, or about three times the size of the largest commercial floating dock previously built in this country.

It is a most remarkable fact that from the building of the two Dodge-Burgess sectional docks, between 1850 and 1860, to the building of this dock in 1899, there was no large floating dock built in this country, and this is still more remarkable when it is considered that there was a constant growth in the shipping and a real demand for larger floating docks.

We will now pass to some illustrations of these docks in use. You can see that a floating dock lifts a vessel up out of the water almost to the level of the pier or wharf, and also how the scaffolding is rigged for cleaning and painting. You will understand that this scaffolding around a vessel in dry dock is the rule rather than the exception, as all work other than upon the under body or those parts below the water line is done while the boat is afloat, and, as the expense of keeping a vessel in dry dock is considerable, every possible facility is provided to execute the work in a short time, both by appliances and large numbers of men employed. The wooden horses on the pier are carefully designed to be strong and light, so that they may be readily carried off and on the dock, and at each side there are uprights hinged to the deck of the dock, which, when not in use, rest against the side, when in an upright position they are secured by iron braces. On one side they have a series of pins which support one end of the scaffolding poles, the other ends of which are carried by ropes, called "slings," from the side of the vessel. Below this scaffolding are the wooden horses, with planks upon them.

A good sample of a large box dock of recent design and construction is one built by James Tregarten & Sons, and now in use in their yard, foot of Seventh street, East river, New York. It is about 2,000 tons capacity, the length on keel blocks is 260 feet, length of box 186 feet 4 inches, and width over all 85 feet. The pumping machinery is operated by electricity, the motor being located and controlled in a small house on the right-hand wing. The current is led from a post on the pier by a flexible conductor.

Fig. 5 shows a smaller box dock of about 1,500 tons capacity. This dock is 130 feet long in the box and 190 feet long on the keel blocks, has a width over all of 68 feet, and will take a draft of 17 feet above 3-foot keel blocks. The body of this dock is

10 feet 6 inches deep, which gives it a very large lifting power for its dimensions. The design was developed particularly for the largest class of ocean-going tugs, having large concentrated weights. The machinery is operated by electricity and the handling of the motor is from the small house seen at the left on the pier. This enables the dockmaster to direct the location of the vessel upon the blocks and to start, stop and regulate the speed of the pumping himself, thus dispensing entirely with an engineer. Keel blocks, bilge blocks and scaffolding are shown.

The next view, Fig. 6, shows a basin dock. I show this for the purpose of comparison, so that those who are unfamiliar with the subject may readily understand how a floating dry dock differs from a basin dry dock. You will see here what appears to be a large opening or basin extending from the surface of the ground to a distance below the surface of the water corresponding to the greatest draft of vessel which it is intended to accommodate. The sides and bottom are made to exclude the water, and a gate which is removable is fitted across the entrance.

When the dock is full of water this gate is removed, and the vessel to be docked enters, and is located over keel and bilge blocks in the same manner as on the floating dock. Then the gate is replaced across the entrance and the pumping machinery is started, and, as the water is gradually removed, the vessel settles down upon the blocks. In this view the *Shamrock II*, well known as a contestant for the *America's* cup, is shown.

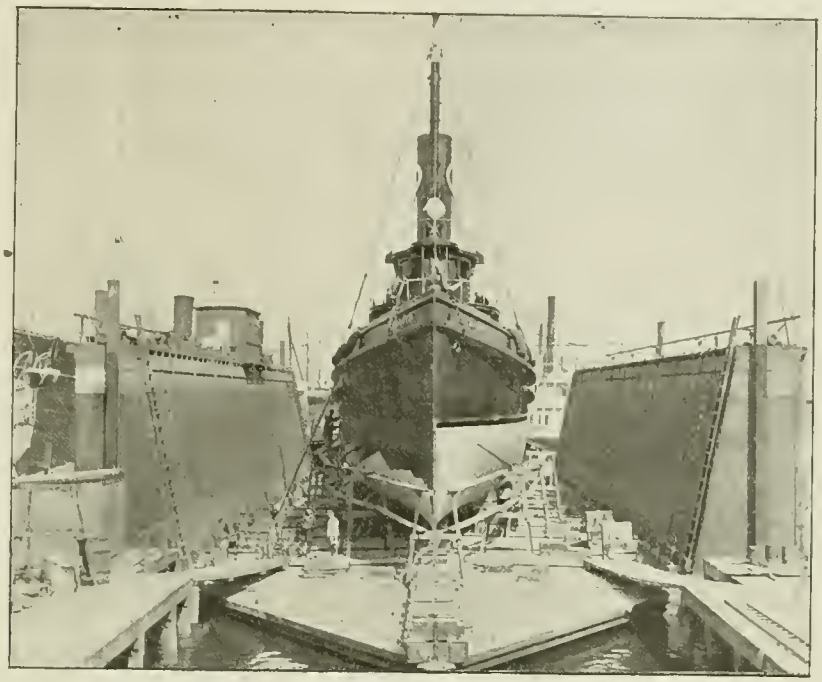


FIG. 5.—BOX DOCK, ELECTRIC DRIVEN MACHINERY.

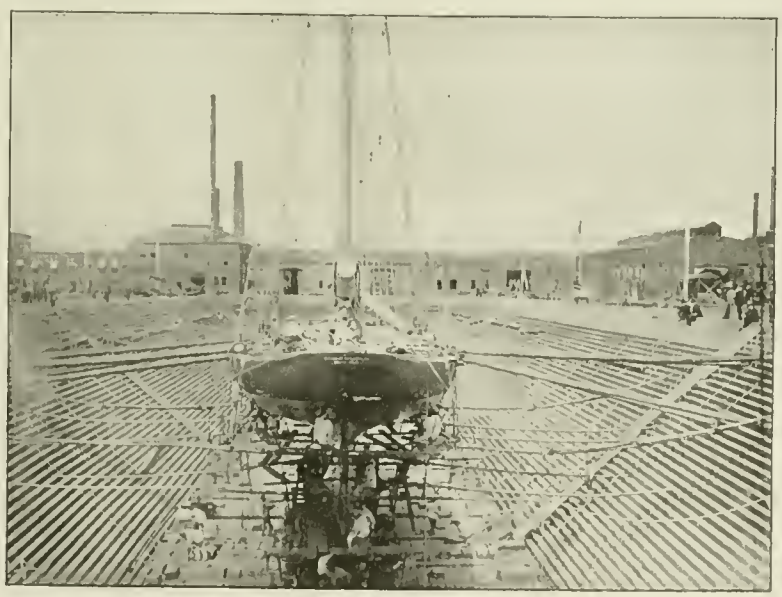


FIG. 6.—BASIN DRY-DOCK, ERIE BASIN, BROOKLYN. YACHT SHAMROCK, 2D.

While basin docks have been built to very much larger size than floating docks, on the other hand, floating docks have been built in much larger numbers, and are generally conceded to be much more handy and workable than basin docks.

(To be concluded.)

INTERNATIONAL MARINE ENGINEERING

Published Monthly at
17 Battery Place - - New York
By MARINE ENGINEERING, INCORPORATED
Christopher St., Finsbury Square, London, E. C.

TERMS OF SUBSCRIPTION

	Per Year	Per Copy
United States, Canada and Mexico	$2.00	20 cents
Great Britain and Ireland	10/6	1/
Other countries in the Postal Union	10/6	1/

Entered at New York Post Office as second-class matter.
Copyright, 1906, by Marine Engineering, Inc., New York.
INTERNATIONAL MARINE ENGINEERING is registered in the United States Patent Office.
Copyright in Great Britain: entered at Stationers' Hall, London.

Notice to Advertisers.

Changes to be made in copy, or in orders for advertisements, must be in our hands not later than the 5th of the month, to insure the carrying out of such instructions in the issue of the month following. If proof is to be submitted, copy must be in our hands not later than the 1st of the month.

The edition of this issue comprises 6,000 copies. We have no free list, accept no return copies and issue only enough to supply the regular demand.

Battleship-Cruisers

Since discussing in our September number the battleship design attributed to the Italian Admiralty, development in this respect has taken place in England which is far reaching in character, and inaugurates a new type of vessel of very great offensive qualities with respect to both gun power and speed. Particulars have just been given out covering the design of three so-called armored cruisers now being built on the Clyde and Tyne.

These ships are to have a displacement of 17,250 tons, with a length of 530 feet and a beam of 78½ feet. Each will carry eight 12-inch guns so arranged that all of these primary guns can be brought to bear at once upon either broadside. This gives them a broadside fire identical with that of the *Dreadnought,* and also the same as that in the two new American battleships.

The great departure in connection with vessels of such extreme offensive gun power is in speed. These ships are to be propelled by steam turbines of such a power as to enable them to attain a speed of 25 knots; it is even asserted that some disappointment will be felt if 27 knots is not attained. It is needless to say that the difference between 25 knots and 27 knots in such a vessel would represent a difference in effective or developed horsepower of from 25 to 30 percent, this representing an increase of at least 10,000 horsepower upon that required for 25 knots. A margin of 10,000 horsepower in the powering of any ship would ordinarily indicate poor design, but when it comes to an instrument of the flexibility of the steam turbine, an overload possibility of 25 or 30 percent, even when it represents 10,000 horsepower, is perhaps not unreasonable. In such a case the only question comes from the possibility that the boilers may not be able to furnish sufficient steam for such an enormous power.

It goes without saying that in order to attain such tremendous speed in conjunction with a very high gun power, sacrifices have to be made in some particular, and we understand that in this case it is the protective portion of the design which has suffered. The details at hand are so incomplete that little can be said in the way of comment upon the relation between speed, gun power and armor, as represented in these ships. With their possibility, however, due to extremely high speed, of choosing at will such fighting distance as best suits them, and with a battery of heavy guns of such power as to be available at a long range, compared with the bulk of the batteries of such ships as will oppose them, the matter of armor becomes one of almost secondary importance.

Fireproof Steamers.

We had occasion last May to comment upon the introduction of fireproof construction in steamers used upon our rivers, sounds and lakes. The leading article in our present number is a description of an excursion steamer for use on the Potomac river and Chesapeake bay, which has been made almost absolutely fireproof by the use of steel partitions everywhere, of asbestos fireproofing wherever necessary, and the abolition of wood construction in various fittings which are ordinarily made of wood and in the covering of much of the wood that is found to be necessary by materials either non-inflammable or very slow burning in character. Not content with this elaborate provision against the possibility of spread of fire, there has been provided the usual system of fire fighting equipment, in the way of pumps, hose and patent extinguishers. The result is a vessel about whose capacity for resisting or overcoming fire in its incipient stages there can be no reasonable doubt.

This sort of construction is doubtless somewhat more expensive than that usually adopted, but the difference in safety to the vessel itself ought to make full monetary return for any such additional first cost. This return is not only on account of the great saving in time and earning capacity which would be made by reason of a lesser liability to being put out of commission by a fire of either large of small dimensions; but also on account of the fact that it would probably be found feasible, even with a small fleet of vessels, to adopt a self-insurance plan, by which the regular premiums would be transferred to an insurance fund.

This would then take care of any fire losses sustained in the operation of the vessel. The enormous saving in total operating expenses brought about by this method of handling fire hazards is well known, being due, of course, to the fact that the insurance rates of the marine insurance companies are so high that there can be no question as to the ability of these companies to take care of all losses sustained by those insuring with them, without the slightest possibility of impairment of their capital. This capital in the present suggested case would be held by the company owning the steamers, and while, of course, the best financiering would not permit it to be considered an available asset of the company, yet in the last analysis it could not but be so considered, and the company would be correspondingly strengthened in that direction.

Aside entirely from the financial status of the case, we must consider the fact that the safety made possible by the use of fireproof construction would provide almost absolute security against loss of life. Not only this, but the very security offered by such construction would be in itself an immense inducement for people contemplating an excursion to patronize a steamer or line of steamers in which such conditions existed. There would thus be on this score still another financial inducement to adopt this method of construction.

There are many ways of looking at the problem, and in every one of them, except that of initial cost, the advantage lies enormously with the method of fireproof construction. In the one feature where the non-fireproof construction has the advantage, this advantage is more than offset by counterbalancing features in the safer method of construction. As developments in this line go on, it would be unreasonable to suppose that cost of production could not be cheapened, and brought perhaps to a figure not far different from the present cost of the less safe construction.

The Mauretania.

Nothing impresses upon one's mind an idea of immensity of any constructional feature of a new ship or building or machine so well as a comparison between that feature and something in common use and prominently in mind. For this reason the photographs reproduced in this number, in which the funnels and turbines of the new steamship *Mauretania* of the Cunard Line are shown with automobiles alongside, are of peculiar interest. Particularly so is the one at the top of page 440, where two motor cars are shown in the act of being driven side by side through a section of one of the funnels. It is seen in the photograph that they by no means fill the space, but that could this immense structure have been of such proportions as to utilize to the best advantage its volume for this purpose, three or four such cars could have been driven through it together. The Cunard Line has a reputation for placing extremely large funnels upon its ships. The *Campania* and *Lucania*, which are thirteen years old, have funnels measuring 26 feet in diameter on the long axis, and at the time of the launching of the former it is reported that a banquet was held in one section of one of the funnels, there being plenty of room for the large banqueting table, with covers laid for twenty-four guests.

Shipyard Management.

One of our articles in this issue gives a somewhat detailed account of the experience of a naval architect in his connection with various shipbuilding plants, private and governmental, all over the United States, but mainly on the Atlantic Coast. We are informed that the picture there drawn of poor management and favoritism is by no means overdrawn, and that this condition of affairs is very largely responsible for the fact that the construction of ships in American yards is so much more expensive than is the case in shipyards in Great Britain and Germany. Our correspondent had an experience along that line probably more extensive and more varied than could readily be found among his fellow workers. He seems to have stuck to his profession with a tenacity worthy of infinitely better results.

Other stories to the same effect, however, have come to our ears from sources the reliability of which cannot be questioned, and we are forced to the conclusion that mismanagement of this sort is an extremely common thing. Mistakes emanating from the use of poorly equipped and poorly paid workers are tremendously more costly than the reimbursement of well equipped and well paid workers and designers for their services. Not only this, but to accomplish the work required, a much larger number of the poorly paid men is found necessary than is the case with men whose professional attainments demand larger salaries and better working conditions. It is simply another case of the old saying, "Penny wise and pound foolish."

The proposed subsidizing of certain lines of steamers in the American merchant marine is expected, if carried into effect, to do an enormous amount of good in the upbuilding of this merchant marine, and in the re-establishment of our shipbuilding plants upon a paying basis, thus giving employment to larger numbers of men, and conducing generally to higher prosperity among those immediately affected. This sort of subsidy, however, can have no effect whatever upon the subject just reviewed, and, unless matters along these lines are remedied from within the profession, there will still be this great handicap to the fullest attainment of the possibilities inherent in our shipyard establishments. The subject is one which calls for careful introspection, with a view to remedying the faults now existing and rendering possible a fuller development of our resources along shipbuilding lines.

NOTES ON STAIRBUILDING.

BY H. S. TAFT.

As little if any information upon the subject of stairways and stair building can be found in the hand books usually referred to by the naval architect, a few notes upon this subject will no doubt be of value to those responsible for the proper solution of the many problems entering into ship construction.

Stairways should be laid out to meet the special conditions of the problem in question, the stairways in primary schools, or in buildings used mostly by children, being built with less "rise" and more "tread" than in the case of stairways used by persons of a more advanced age. Where there is plenty of room, or where ease and comfort in climbing are desired, a rise of 6 inches with a tread of 12 inches is considered the ideal condition. The ordinary stairway has a rise of 7 inches with a tread of 10 to 11 inches, though the back stairways of houses usually have a rise of 8 inches with a tread of 9 inches, the stairway being somewhat steeper than in other cases. The ladders used by fire departments have their rounds spaced about 12 inches center to center.

With all the varieties of solution, there still remain certain rules as regards the relation of rise to tread, almost universally employed by stair builders. Expressed in the form of equations they are:

$R \times T$ to be not less than 70, not more than 75;

$R + T$ to be not less than 17, not more than 18;

$2R + T$ to be not less than 23, not more than 25;

where R = rise, and T = tread. Considering that $R \times T = 72$, a diagram has been constructed, Plate No. 2 (the heights or total rise of the stairway being used as ordinates, and the spread or total tread being used as abscissae) by which the number of steps necessary in any given case to comply with the above equation, $R \times T = 72$, can be quickly determined.

To use this diagram, when the total height and spread of the stairway are given, it is necessary only to find the intersection of the horizontal and vertical lines corresponding respectively to the given height and spread of the desired stairway, and the nearest curved diagonal line will be the number of steps necessary. As an example, with a height of 8 feet and a spread of 12 feet, it will be found that 14 steps comes nearest to fulfilling the requirements. With the same height, and a little more spread, 12 feet 3 inches, it will make the rise and tread product just equal to 72, whereas, in the case of 8 and 12 feet, the product would be 70.5.

When the "slope" of the stairway is given, and it is desired to determine a satisfactory rise and tread, draw in the slope line from zero of diagram (upper left hand corner) and the intersection of this line with the diagonal curved line for 12 steps will give the proper relation of rise to tread to suit the equation of $R \times T = 72$. (In this case "height" and "spread" in feet on the diagram become respectively "rise" and "tread" in inches.)

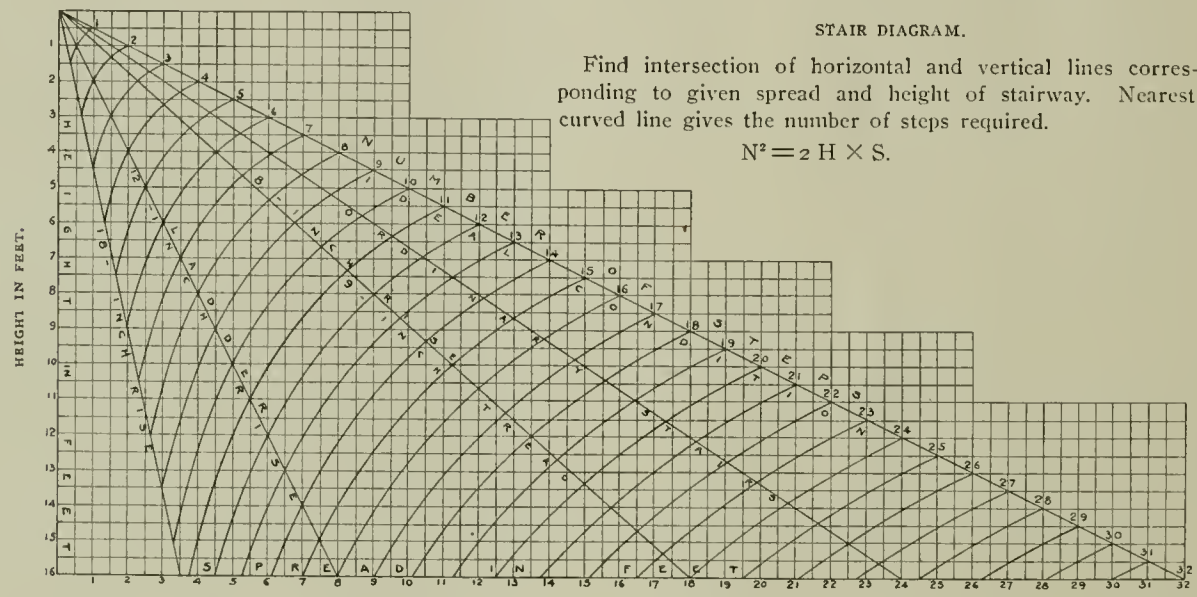
For a given rise or for a given tread (using height and spread in feet as rise and tread in inches), by finding the intersection of the corresponding horizontal or vertical line with the diagonal curved line for 12 steps, the corresponding vertical line or horizontal line will give the desired tread or rise to satisfy the above equation.

Where the space allowed for a stairway is restricted, and a steep set of stairs results—as in yacht design—it is the general practice to recess one step under another, 1¼ inches being the maximum allowance of recess. Some yacht builders use a universal rise of 8 inches with a tread of 6 inches.

STAIR DIAGRAM.

Find intersection of horizontal and vertical lines corresponding to given spread and height of stairway. Nearest curved line gives the number of steps required.

$N^2 = 2\,H \times S.$



The ordinary thickness of a wooden tread is 1⅛ inches, though it varies from ⅞-inch to 1⅝ inches. A wooden riser is usually ⅞ inches thick, being dovetailed into both steps, with a small beading across the top.

Where hand rails are used with stairways, they should be placed between 2 feet 5 inches and 2 feet 8 inches above the steps, measured vertically on a line with the face of the riser (outer edge of step), 2 feet 6 inches to top of rail being considered the best practice. Railings around wells or on landings should be from 2 feet 8 inches to 3 feet high.

NOTES TO ACCOMPANY TABLE.

1. ⅝-inch round iron "spills" should not be used for spans over 18 inches.

2. ¾-inch round iron "spills" should not be used for spans over 27 inches.

3. For wider spans, additional supporting bars, of the same section as the side bars, should be used.

4. Ladder step should be from 9 to 10 inches apart (face to face).

5. Cast iron step should have rounded corners and be attached to the side bars by two ½-inch bolts at each end.

6. The main engine room ladder should be 21 inches wide if possible, but 24 inches in large ships, where plenty of room is to be had. Stoke-hold ladders need not exceed 18 inches in width. Said ladders are usually built with round bar-iron steps.

LADDERS AND GRATINGS.

Ladders							"Spill" Gratings			
Width of Ladder	Size of Side Bars for Cast Iron Steps	Size of Side Bars for Round bar Iron Steps	Width of Cast Iron Steps	Bar Iron Steps Number	Bar Iron Steps Size	Bar Iron Steps Pitch	Width of Grating	Size of Side Bars	Diameter of "Spills"	Pitch of "Spills"
12 Inches	—	2¼ × ⅜	—	1	⅝	—	15 and 18	2¾ × ⅜	⅝	2¼
15 "	—	3¼ × ⅜	—	2	⅝	1⅜	21	3 × 7/16	¾	2⅜
18 "	3½ × ⅜	3½ × ⅜	4¼	2	⅝	1½	24	3 × 7/16	¾	2⅜
21 "	3¾ × 7/16	—	4¾	—	—	—	27	3 × 7/16	¾	2⅜
24 "	4 × 7/16	—	5¼	—	—	—	30 & above	3 × 7/16	*a* ⅝	2¼

a With a Center Support. All Sizes are in Inches. FROM SEATON.

7. The inclination of the main engine room ladder should be 1 in 2¼ when possible.

8. Hand rails should be 1 inch in diameter.

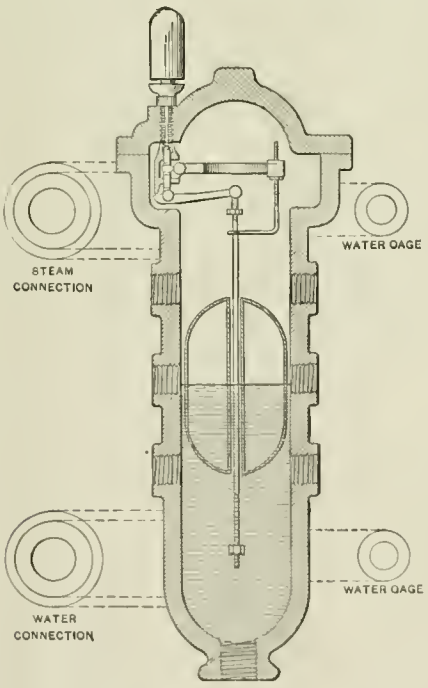
9. Stanchions, when 3 feet in height, should taper from 1 inch diameter at the top to 1¼ inches at the bottom; when short, for ladders, ⅞ inches at the top to 1 inch at the bottom is enough. The ball for the rail to pass through should be 2 inches in diameter.

10. The engine room chequered floor plates should be 5/16 inches thick; and the boiler room plates ⅜ inches, exclusive of the raised pattern. In the navy ¼-inch and 5/16-inch respectively are used.

ENGINEERING SPECIALTIES.

High and Low Water Alarm Columns.

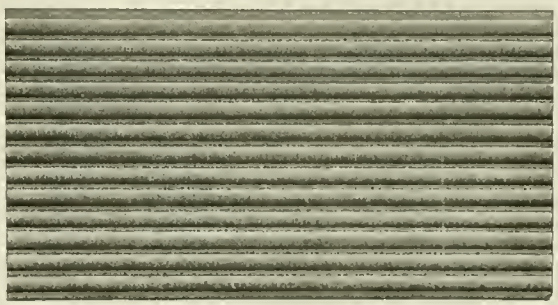
The Turner combined water alarm column is designed to give automatic notice when the water in a boiler gets above or below a pre-determined desired height. The cut shows the general



construction, which includes a seamless copper float, operating the whistle at such points as may be determined by the setting of the valve. The columns are made in five sizes, of extra heavy design, and suitable for any pressure. Steam and water pipes are connected direct to the body of the column, permitting the removal of the cap without disconnecting either pipe. They are placed upon the market by the Binghamton (N. Y.) Machine Tool Works.

Wrought Steel Floor Plates.

Produced in a variety of patterns, including diamond, ribbed, and checkered patterns, the floor plates placed upon the market by the Sligo Iron & Steel Company, of Pittsburg, are designed



for use in boiler and engine rooms, for deck plates and gutter plates, platforms, sills and stair treads, or any place on board ship where a rough serviceable surface is desired. They are rolled from steel boiler plates, and weigh approximately three pounds per square foot for each sixteenth of an inch of body thickness. The plates are made in a variety of widths running up to 50 inches, and in lengths as great as 12 feet.

TECHNICAL PUBLICATIONS.

Brazing and Soldering. By James F. Hobart. Size, 5½ by 8 inches. Pages, 33; illustrations, 16. New York, 1906. The Derry-Collard Company. Price, in paper covers, 25 cents.

This little book is No. 5 of a series of practical papers being issued by the publishers, and gives practical advice regarding the two closely related subjects of brazing and soldering. The arrangement of gas and air pipes for use in brazing furnaces, the use of small blow pipes and of soldering irons and the various other devices used for these purposes, are illustrated and described, together with the necessary solutions for cleaning the surfaces to be operated upon, and for use as fluxes.

Directory of the Alumni of Stevens Institute of Technology. Size, 4½ by 7¼ inches. Pages, 132. Hoboken, N. J., 1906. Published by Stevens Institute Alumni Association. Price, $0.50.

This is a directory in three parts, of which the first two are respectively alphabetical and geographical lists of the alumni, while the third is a business directory in such detail that many of the men are listed under several separate headings.

Wiring a House. By Herbert Pratt. Size, 5½ by 8 inches. Pages, 21; figures, 6. New York, 1906. The Derry-Collard Company. Price, in paper covers, 25c.

This little book gives practical advice as to methods to be used in both designing and installing an electric circuit in a house. The principal use of the current would be for lighting, but, of course, it could be used to some extent for other purposes.

Management of Electrical Machinery. By Francis B. Crocker, E. M., Ph.D., and Schuyler S. Wheeler, D. Sc. Size, 4¾ by 6¼ inches. Pages, 223; illustrations, 131. New York, 1906. D. Van Nostrand Company. Price, $1.00 net.

The present work, which is the sixth edition, is a thoroughly revised and enlarged edition of "The Practical Management of Dynamos and Motors." It covers the subjects of the Selection and Management of the various machines found in power houses; Inspecting and Testing these machines; the Localization of Troubles and the Remedies Therefor; and Constant Current Generators for use in connection with arc lighting.

The basic principles of generators and motors are taken up very briefly, much information being given upon practical details in the way of direct and belt drive, chain drive, etc., after which the various details of wiring and fuse connections are discussed. Diagrams are given showing the operation of machines under varying conditions, while the instruments of measurement are described at some length. The subject of Power and Efficiency is given a separate chapter, while the subject of Troubles is treated in considerable detail. A complete index at the rear adds its quota to the value of the work.

Manual of Wireless Telegraphy. By A. F. Collins. Size, 4¾ by 7¼ inches. Pages, 232; figures, 90. New York, 1906. John Wiley & Sons. Price, bound in cloth, $1.50 net; morocco, $2.00 net.

The purpose in the preparation of this manual was to give detailed and explicit instruction for wiring various types of sending and receiving apparatus now in general use, the adjustment of the instruments, tuning and syntonizing the circuits, testing the devices, and the management of ship and shore stations. It was realized that the most proficient operators are those who combine in highest degree theory with practice. If the principles involved in the system under operation are clearly understood, the adjustment and manipulation of a tool is much easier than where the results are groped after blindly. It was to furnish this information that the book has been issued, many of the difficulties usually encountered being explained in such a manner that the operator may easily overcome or circumvent them. The subject is gone into with considerable detail, and is well illustrated with both line drawings and half tones.

The different makes of equipment are explained, a list is given of stations and liners equipped with the Marconi apparatus, and another list of De Forest stations and ships, while the United States Navy ship and shore stations are outlined.

In the rear of the book are to be found a chart of the Atlantic ocean communication lines of various steamships and operating stations under the Marconi system; also a bibliography of books covering the subject, in English, French, German and Italian. A glossary of wireless telegraph words, terms and phrases, and an unusually complete index end the volume.

Technical Dictionary. Volume I: Machine Details and Tools. Compiled by K. Deinhardt and A. Schlomann. Size, 4 by 7 inches. Pages, 403; illustrations, 823. New York, 1906. McGraw Publishing Company. Price, $2.00 net.

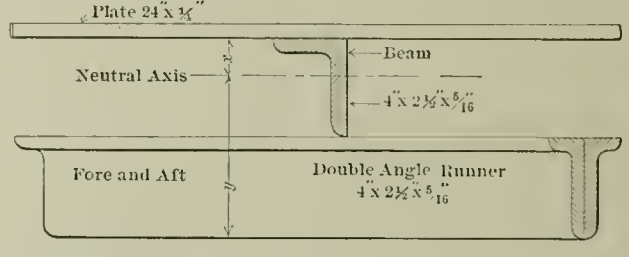
This is the first of a series of similar technical dictionaries published in six languages; English, French, German, Russian, Italian and Spanish, and is intended as an assistance to the engineer in the reading and study of technical articles and books. The work contains three distinct parts: an index, a systematic arrangement of the text, and an alphabetical index of the words. Each item mentioned or described is given in all the six languages and a large portion of the items are illustrated by small line cuts in such manner as to readily identify the terms as used. The index of words is arranged in two sections, the first including the five languages using the Latin characters, while the other section is devoted to the Russian language. The general scope of the work is such as to commend itself to those whose duties call upon them for frequent use of other languages in connection with technical subjects, and as the entire scheme embraces a total of eleven volumes, classified as to the general subjects included, the possession of one or two or more of these volumes by each engineer interested should enable him to take care of any work of this character along his own special line.

The remaining volumes which are yet to appear are as follows: Electric plants and machines; Steam Boilers and Engines; Hydraulic Machinery; Hoisting and Conveying Machinery; Small Tools and Machine Tools; Railways and Locomotives; Structural Iron Work and Bridges; Metallurgy; Architecture; and Naval Construction.

QUERIES AND ANSWERS.

All reasonable questions concerning marine engineering received from and signed by subscribers will be answered by the Editor in this column. All communications must bear the name and address of the writer.

Q. 345.—I inclose calculation of neutral axis and moment of inertia of beam and deck; also of beam under deck with double angle runners attached. The first works out (according to my calculation) as =0.87; the second as 3.71. What have I proved? Can I express it in tons? Assume



an ordinary ship's frame with reverse bar. How can I calculate an equivalent Z bar? Would not sectional area do, or must I work out a moment of inertia?

I presume this moment of inertia would apply to timber as well as steel.

Far Off Subscriber.

PLATE AND BEAM.

Items	Dimensions	Area	Leverage	Moment	Moment of Inertia
Plating	24 ×.25	6.000	− .125	− .750	.125
Horizontal Flange	2.188×.312	.683	.156	.106	.221
Vertical Flange	4 ×.312	1.248	2.000	2.496	6.656
		7.931		1.852	7.002

$\frac{1.852}{7.931}$ = 0.233, locating neutral axis below under side of plate. I = 3.767 inches.

PLATE AND BEAM WITH RUNNER.

Items	Dimensions	Area	Leverage	Moment	Moment of Inertia
Plating	24 ×.25	6.000	− .125	− .750	.125
Horizontal Flange	2.188×.312	.683	.156	.106	.221
Vertical Flange	4.000×.312	1.248	2.000	2 496	6.656
Runner, Horizontal Flange	2.188×.312	.683	4.156	2.839	11.790
Runner, Vertical Flange	4.000×.312	1.248	6.000	7 488	46.590
		9.822		12.177	65.382

$\frac{12.177}{9.822}$ = 1.24, locating neutral axis. I = 6.76 inches.

A.—The moment of inertia in the first case is not 0.87 but is 6.571, this being the figure obtained by our subscriber, and then put through another operation which we do not understand. In the second case, the moment of inertia would be similarly 50.275, were it not for the fact that the fore-and-aft runner under the

beams has nothing whatever to do with the transverse stiffness of the vessel, and, therefore, cannot enter into the computation for a moment of inertia in this direction. As a result, the moment of inertia is 6.571, as before.

The calculation appears to be based on a beam spacing of 24 inches, and has been made without reference to the cutting of beam and plate for rivets. Such parts of the section as are under tension at any given moment will properly have moments of inertia less than that calculated, by an amount varying from 12 to 17 percent, depending upon the character of the riveting. Portions under compression would have no deduction for rivet holes, providing the rivets were well driven. The total deduction to be made in a case like this would probably be not far from 6 to 8 percent of the total, thus leaving the moment of inertia of the plate and beam at about 6.2, in each case.

The moment of inertia of any such beam is merely a mathematical quantity which is used in connection with the resistance of the beam to bending. It is expressed in inches raised to the fourth power; that is, in square inches times square inches, and not in tons.

In a comparison between an ordinary ship frame and reverse bar on the one hand and a Z-bar on the other, the sectional areas of the two, if the depth is the same, would be approximately proportional to the moments of inertia. In order, however, to obtain an exactly equivalent Z-bar to any given combination of frame and reverse frame, a regular calculation for moment of inertia would have to be made for each case, the proper Z-bar being determined by a process of trial and error. One or two approximations in the hands of an experienced operator would give results as close as might be desired.

The subject of moment of inertia has to do with the form and position of the various members of a structure undergoing examination, and has really nothing to do with the quality of the material making up that structure. The latter item enters the calculation when the subject of strength is being examined. The formula for the stress in a member of this sort is $p = \frac{M c}{I}$ where p is the maximum load on the member, in pounds per square inch of section; M is the bending moment expressed in inch pounds; c is the distance from the neutral axis to the outermost portion of the member, and I is the moment of inertia, expressed as above in biquadratic inches. It is in comparing p with the unit strength of the material to be used that the quality of this material enters the problem.

Q. 356.—What power will it take to drive a flat bottom stern wheel boat 24 feet long, 8 feet beam with uniform draft fore and aft at 6 miles per hour in dead water? The displacement is 2½ tons.
How many revolutions per minute would be required to make that speed with a wheel 6 feet in diameter carrying ten 9-inch blades, 7 feet long?
What would be the percentage of slip? R. M.

A.—Referring to page 279 in our issue for July, a formula is found which will give approximately the required power in the case of any small boat, where sufficient data is at hand to make the computation. Judgment is necessary in applying this formula, which is:

$$H = \frac{A B}{K}$$

In this case H is the horsepower; A is a factor depending upon the displacement; B is a factor depending upon the speed, and K is a factor to be selected by judgment, and depending upon the form of the hull as compared with the results to be attained.

In the present case $A = 3.15$; $B = 216$; K is taken at 250 for a vessel of this character, and the result gives 2.72 horsepower required. It therefore follows that if an engine of 3 horsepower be fitted, it could be reasonably expected that a speed of 6 miles per hour would be attained.

Under ordinary conditions a slip of about 20 percent might be expected. It thus follows that a speed of 6 miles per hour would mean $\frac{6 \times 88}{1 - .20}$ or 660 feet per minute for the blades of the wheel. As the mean diameter is 6 feet, the circumference would be 18.85 feet, and the number of revolutions per minute would be 660 ÷ 18.85 or about 36.

Q. 357.—Is block coefficient simply the immersed portion of the vessel subtracted from an oblong, or block, having the same length, breadth and draft as ship? Does coefficient of fineness mean the load water area or L. W. L. plane subtracted from an oblong with the same length and beam as vessel? What is considered a ton in shipbuilding, 2,000 pounds or 2,240 pounds? J. D.

A.—The block coefficient is the ratio between the volume of the immersed portion of the vessel and the volume of an oblong block having the same length, breadth and draft as the ship. The coefficient, as stated above, is a ratio or proportion.

The coefficient of fineness is a term which is used for a great many such ratios, as explained at page 245 in our issue for June, 1906. In the special case of the load water plane; the coefficient of fineness of that plane is the ratio between the area of the plane and the area of an oblong of the same length and breadth.

In shipbuilding, a ton is universally the gross ton of 2,240 pounds, instead of the net ton of 2,000 pounds.

Q. 361. (1).—If steam in a boiler rises from low to high pressure simply by the addition of heat, why does not the addition of superheat to the steam in pipes connected directly to the boiler raise the pressure? In other words, why does not superheat raise pressure?
(2) What is saturated steam saturated with: water, watery vapor or heat? What is steam-saturation? D. H.

A.—(1) If steam were a perfect gas, the addition to it of heat would invariably increase the pressure in an amount proportional to the addition of heat. As a matter of fact, however, steam behaves differently from a perfect gas, and it is found possible to add heat without corresponding increase in pressure. This added heat raises the temperature of the steam and produces what is known as superheated steam, the increase in pressure due to this addition of heat being almost negligible. Steam cannot exist at a lower temperature than that corresponding with its pressure; but, as mentioned above, it can exist at a temperature *higher* than that corresponding with its pressure. As soon as the temperature is lowered below that corresponding with the pressure, a certain amount of condensation takes place, thus automatically keeping the pressure down at least sufficiently low to correspond with the temperature.

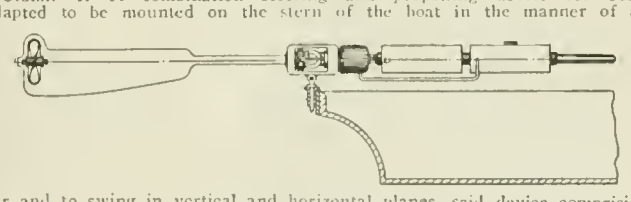
(2) The term "saturated steam" covers a condition of steam in which the amount of water vapor contained is exactly equal to the amount which the steam can absorb without showing perceptible moisture. Any quantity of vapor greater than this would be precipitated in the form of moisture or condensation, while a lesser quantity would result in the steam's being superheated. The term "saturated steam," or, as it is frequently written, "dry and saturated steam," involves an apparent contradiction from the usual acceptation of the word "saturate." As explained above, however, the expression is used for simply one point in the curve showing the quantity of vapor contained in the steam, namely: that at which the steam is neither moist nor superheated, but is on the dividing line between the two.

SELECTED MARINE PATENTS.

The publication in this column of a patent specification does not necessarily imply editorial commendation.

827,202. MEANS FOR PROPELLING AND STEERING OR GUIDING BOATS. HENRY BACHMAN, NEW YORK.

Claim.—1. A combination steering and propelling device for boats adapted to be mounted on the stern of the boat in the manner of an

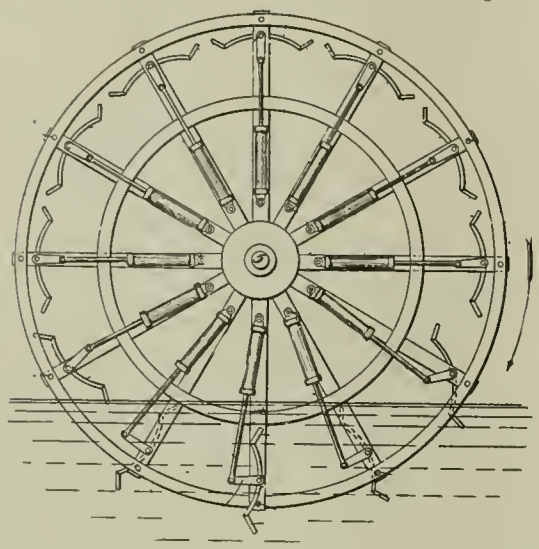


oar and to swing in vertical and horizontal planes, said device comprising an oar-blade member provided with a tubular shank, a handle member and a framework or casing connecting the tubular shank of the oar-blade member and said handle member, a shaft mounted in the oar-blade member and provided at its outer end with a propeller and at its inner end with

a beveled gear-wheel, two cylinders mounted in the opposite sides of the framework or casing and provided with pistons and piston-rods geared in connection with said bevel gear-wheel, and means for operating said pistons. Two claims.

827,216. FEATHERING PADDLE-WHEEL. WILLIAM N. CRUCHON, SEATTLE, WASHINGTON.

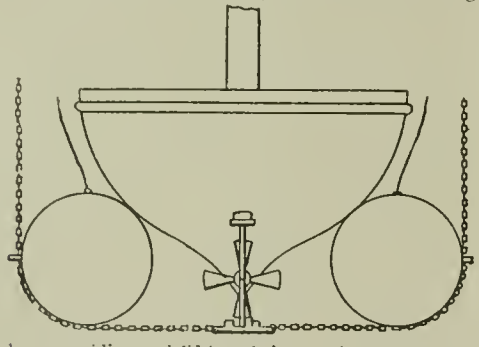
Claim.—5. In a paddle-wheel the combination of a bucket pivotally connected thereto, means carried by the buckets for tilting the same as



said means come in contact with the water, and spring actuated means for returning said bucket to its normal position after it has emerged from the water. Five claims.

827,477. MEANS FOR RAISING SUNKEN VESSELS. JOAO GONCALVES FERREIRA TITO, RIO DE JANEIRO, BRAZIL.

Claim.—1. The combination with caisson-buoys each provided with means for exhausting water therefrom, of automatic clutch-guides upon



said caisson-buoys, guiding and lifting chains passing through said automatic clutch-guides, supporting-plates attached to the lower ends of said guiding and lifting chains, and coupling chains connecting adjoining supporting-plates. Two claims.

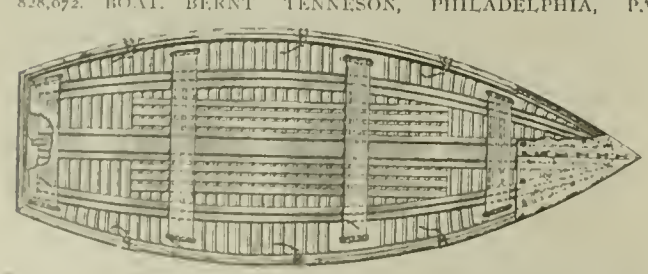
827,619. PROPELLING MECHANISM FOR VESSELS. WALLACE W. COX, PUNGO, VA.

Abstract.—This invention has for its object to provide a simple and effective motor-driven propelling mechanism of the side-wheel type for launches and other small vessels, the same embodying friction-gearing readily controllable to stop the vessel and propel it forward and backward at will. One claim.

827,916. SUBMARINE TELEGRAPHY. ISIDOR KITSEE, PHILADELPHIA, PA.

Claim.—1. Means to translate the received impulses of submarine or other cables, said means embracing a receiving device provided with a free swinging coil, mechanical means adapted to move in unison with said swinging coil, a local circuit, a source of current for said circuit, a transmitting device for said circuit and means whereby through the contacting of part of the mechanical means with part of the receiving device a shunt around part of the translating device is made or broken. Two claims.

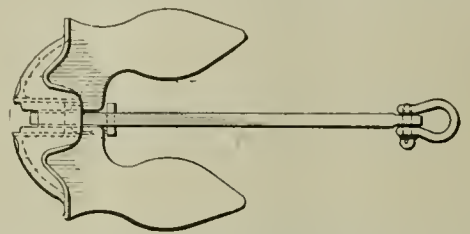
828,072. BOAT. BERNT TENNESON, PHILADELPHIA, PA.; OLEVINE TENNESON AND WILLIAM H. BAKER, EXECUTORS OF SAID BERNT TENNESON, DECEASED.



Abstract.—The objects of the invention are to furnish an improved means for securing the upper sides of the canvas cover to the wooden inner part of the boat, to furnish an improved means for detachably securing the thwarts to the boat, and to furnish an improved means for securing in place a detachable square stern. Three claims.

828,757. ANCHOR. FRANK S. MANTON, PROVIDENCE, R. I., ASSIGNOR TO THE AMERICAN SHIP WINDLASS COMPANY, PROVIDENCE, A CORPORATION OF RHODE ISLAND.

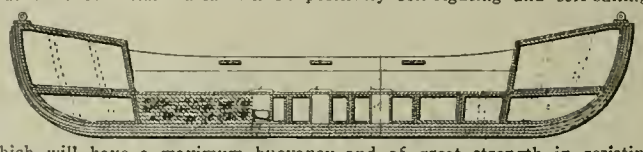
***Claim.*—2.** In an anchor, the combination with a scalloped head-piece having two oppositely-extending shoulders carrying flukes and two



hook-shaped shoulders extending in opposite directions at right angles to the plane of said flukes, said head-piece having a series of perforated pockets one arranged opposite each scallop and between adjacent shoulders, of a shank having pivotal connection with said head-piece. Four claims.

828,852. LIFE-BOAT. OLIVER R. INGERSOLL, BROOKLYN, N. Y.

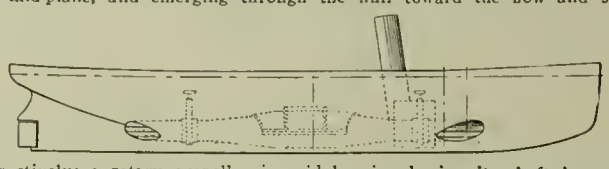
Abstract.—The invention relates to improvements in boats of that class or style denominated "life-boats;" and the objects are to provide such a boat built of metal which will be positively self-righting and self-bailing,



which will have a maximum buoyancy and of great strength in resisting the exigencies of the service, and which is capable of withstanding the effects of accidental or intentional puncture by bullets or other missiles. Two claims.

829,033. MEANS FOR VESSEL PROPULSION. THOMAS RONSTROM, CHICAGO, ILLINOIS.

Claim.—1. A vessel having a substantially cylindrical propeller housing or waterway at the lower part of the hull having its axis in the vertical mid-plane of the hull; two water-passages leading from each end of said housing or waterway symmetrically disposed with respect to said vertical mid-plane, and emerging through the hull toward the bow and stern



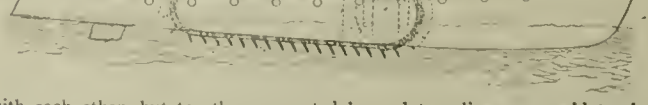
respectively; a rotary propeller in said housing having its shaft journaled at the end thereof between the two water-passages at each end, said housing having a cap at the upper side, removable for access to the propeller, and water-gates in each of the four water-passages Two claims.

829,054. LIFEBOAT LOWERING AND HOISTING APPARATUS FOR USE ON SHIPS. JOHN BOAG, KEARNEY, N. J.

Claim.—4. In an apparatus of the class described a horizontally-arranged davit-shaft, davits connected with said shaft and adapted to turn therewith, means for limiting the movement of said shaft, a transversely-arranged shaft geared in connection with said davit-shaft, means for operating the transversely-arranged shaft, a drum divided into two parts, ropes connected with the separate parts of said drum and arranged to suspend a boat from said davits, said ropes being adapted to be wound on or unwound from said drum according to the direction in which the drum is turned, and means for operating said drum, said drum being also provided with a brake and with a lock. Eight claims.

829,378. PROPELLING MECHANISM FOR VESSELS. PETER A. COUPAL, BOSTON, MASS.

Claim.—1. A propelling mechanism for vessels, comprising a plurality of circuit-tracks suspended from the body of the vessel, and in part extended below the bottom thereof; a train of paddle-trucks disconnected



with each other, but together supported by and traveling upon said tracks; a sprocket-wheel constructed and arranged to engage in succession the paddle-trucks and to propel the same along said tracks; and means for turning said sprocket-wheel. Two claims.

James Donald, naval architect of the New York Shipbuilding Company, Camden, N. J., was married September 29 to Miss Elizabeth Moore. Mr. Donald, who is a native of Glasgow, came to the United States about ten years ago, since when he has been prominently identified with the largest shipbuilding companies in this country.

International Marine Engineering

DECEMBER, 1906.

THE ENGLISH BATTLESHIP DREADNOUGHT.

Greater interest has been manifested in the design and construction of the battleship which we illustrate herewith than has been the case with any previous naval construction in many years. This is not only due to the great celerity with which the ship was built, but also, and more markedly, to the extremely high military qualities which she possesses.

The *Dreadnought* has a displacement of 17,900 tons, the length between the perpendiculars being 490 feet, while a beam of 82 feet makes her the broadest war vessel afloat. She is fitted with four screws operated at a maximum of 300 revolutions per minute by turbine engines of the Parsons type, designed to develop 23,000 horsepower. Steam is furnished by eighteen Babcock & Wilcox boilers, working under a pressure of 250 pounds per square inch, and fitted for operation with either coal or oil fuel. Each boiler has twenty elements. The total grate surface is 1,560 square feet, and heating surface 55,400 square feet, the ratio being 35.5 to 1. The boilers are arranged in three stoke holds and the products of combustion are discharged through two funnels, the after one being of very large size.

The trials of this ship were very satisfactory, there having been a considerable series for the purpose of learning all that was possible to ascertain about the operation of the machinery. A thirty-hour trial on October 3 and 4 at about one-fifth power showed a total horsepower for the four turbines averaging 5,013, with a corresponding speed of ship of 13 knots. The steam pressure in the boilers was 220 pounds; at the engines, 210 pounds. The revolutions of the inner shafts averaged 205 per minute; of the wing shafts, 182 per minute. The power developed on the inner shafts averaged 1,709 for each shaft, while the outer shafts showed an average of 797 horsepower each. The coal required per horsepower per hour figured out at 2.6 pounds.

STERN VIEW OF THE DREADNOUGHT, SHOWING THE IMMENSE BEAM OF THE SHIP.
(Photograph, Cribb, Southsea.)

On October 4 progressive trials at various powers were run, lasting in each case from one to two hours and varying in the power developed from 1,303 to 15,875 horsepower. The steam used per horsepower hour was shown to decrease from 58.5 pounds at the lower power to 16.6 pounds at the higher.

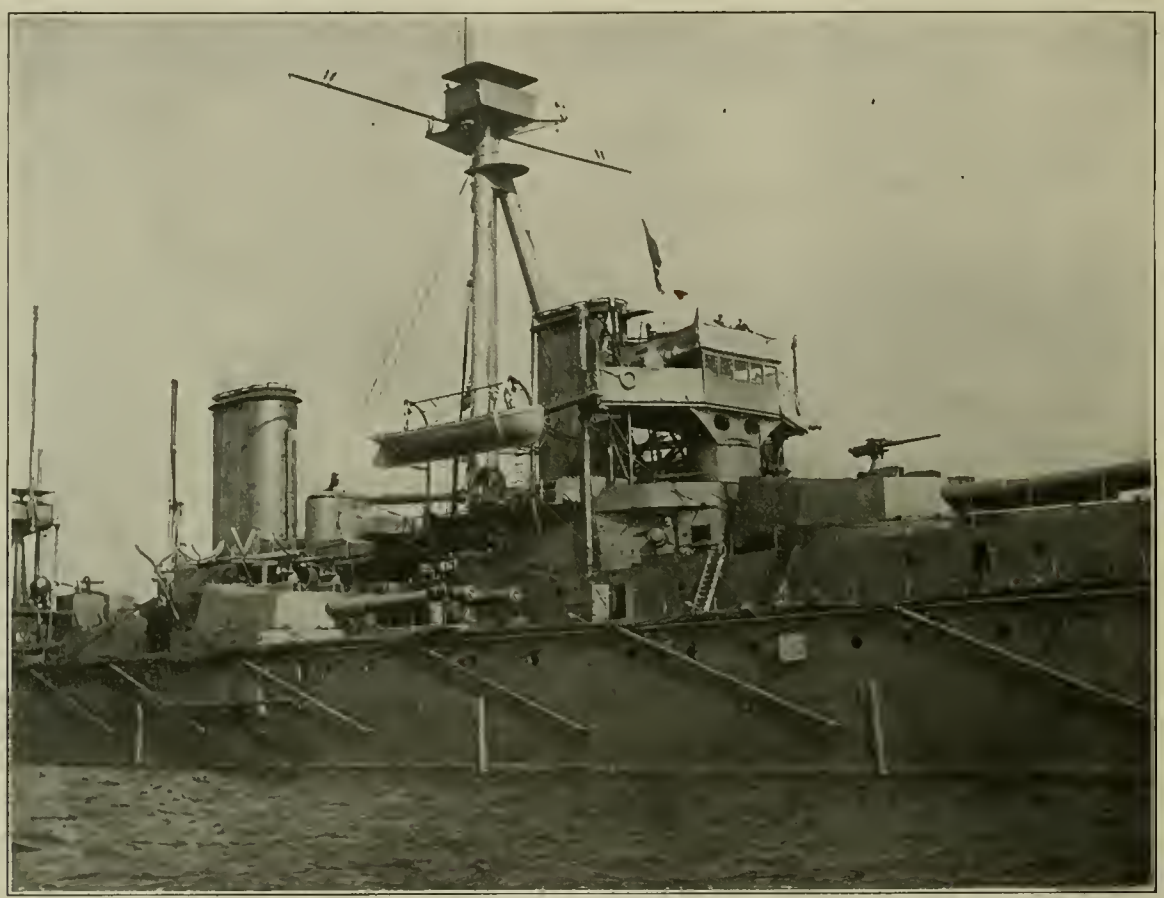
Trials over the measured mile at seven-tenths power showed a total of 17,698 horsepower, with a corresponding speed of 19.42

knots, this having been attained with the shafts operating at an average of 298 revolutions per minute. A thirty-hours' trial at this same power with a pressure of 232 pounds on the boilers showed a total of 16,930 horsepower, a speed of 19.3 knots, a fuel consumption of 1.7 pounds per horsepower hour, and a mean of 291 revolutions per minute.

Full power trials were run October 9, 1906, that over the measured mile having shown an average of 27,518 horsepower with 21.6 knots, and with an average of 337 revolutions per minute. The eight-hours' full power trial took place this same day, the steam pressure in the boilers being 241 pounds. The speed of 21.25 knots was developed with an average of 24,712 horsepower, the propellers operating at a mean of 329 revolutions per minute. The coal burned per indicated horsepower per hour figured out at 1.51 pounds, the steam having been 15.56 pounds, and water evaporated per pound of coal 10.03 pounds. The slip of the propellers at full speed was found to be 26 percent, and at 19½ knots 21 percent. The horsepower of the engines was measured directly by means of torsion meters of the Denny & Johnson type, which measure the angular distortion of the shaft itself.

The battery, which is the most powerful ever yet placed upon any ship of war, consists in the main of ten 12-inch guns mounted in pairs in five turrets, as shown in the illustrations. Three of these turrets are on the center line, one being forward on the forecastle deck, one aft on the quarter deck, and one aft of the funnels, but forward of the after turret, and on the same level with it. The other two turrets are mounted, one upon either beam, well forward of the waist, and serve to give the tremendous bow fire accruing from six guns of such extreme power. The broadside fire, as is seen, is from eight of these guns, which is the same as that given the two new American battleships *Michigan* and *South Carolina*, though it is stated that the English ship has guns of higher power.

With her great length and great size, this ship would be able to maintain her speed in a seaway to a much higher degree than is the case with most vessels against which she would have to contend. She is the equal in speed of most of the fast armored cruisers belonging to her rivals, and, of course, of overwhelmingly superior offensive power. Not only is her battery immensely superior to that of any other battleship afloat, but her extremely high speed will enable her to choose such a fighting distance as would best suit her own peculiar qualities, and crush an enemy with a concentrated fire of eight heavy guns, against which no other battleship afloat could oppose more than four, and these in the main of inferior individual power.



VIEW SHOWING DETAILS OF THE EMPLACEMENT OF TURRETS AND CONTROL STATIONS. NOTE THE TRIPOD MAST.
(Photograph, Cribbs, Southsea.)

Among the many innovations introduced into the design and construction of this ship, that one most apparent to the observer is the form of the forward mast, which is a tripod. This obviates all necessity for stays, and renders the mast much less liable to be destroyed by a single heavy shell than is the case with previous ships. Another novelty is in the location of officers' quarters forward, with the crew aft. Maneuvering power has been largely aided by the fitting under water of a double stern and two rudders. The deadwood is completely cut away, and the rudders, which are quite 20 feet apart, are of the balanced type. This reduces materially the strain on the steering gear, which is of the Napier Brothers type.

Much praise has been bestowed upon the plant of Babcock & Wilcox boilers, constructed by the builders of the machinery. Messrs. Vickers Sons and Maxim, Limited, Elswick, England. On the trials nearly 17 horsepower was developed per square foot of grate area, and maintained for lengthened periods.

BOW OF THE DREADNOUGHT DURING ANCHOR TRIALS, SHOWING THE TOWERING FORECASTLE.
(Photograph, Cribb, Southsea.)

FLOATING DRY-DOCK CONSTRUCTION.

BY WILLIAM T. DONNELLY.

(Concluded.)

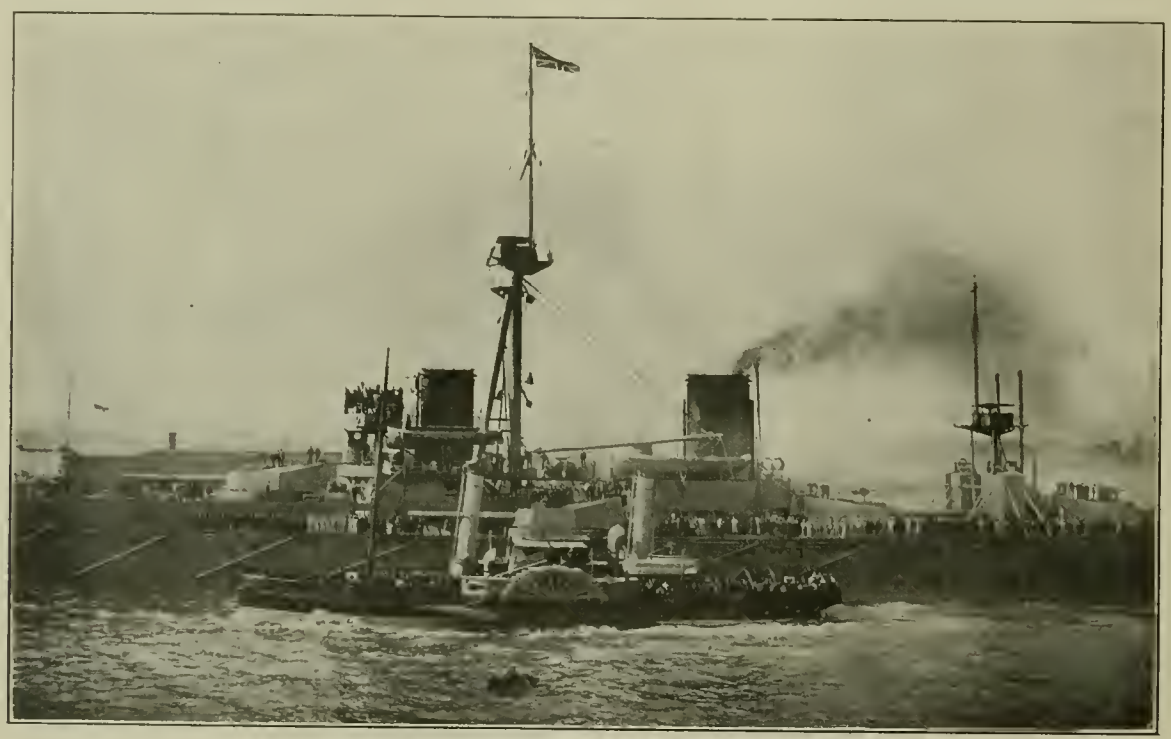
OPERATION OF FLOATING DOCKS.

We will now take up the operation of floating dry docks along lines which will be of more particular interest to those who are already familiar with the subject.

With the first form of dry dock of which we have any record in this country, as previously explained, if it can be grounded, or rest upon the bottom when being pumped out, and if it does not float until it is practically empty, it will operate all right, but if any considerable amount of water is present at the time it floats, one end will certainly be slightly heavier than the other, consequently this end will sag down, and the water will flow towards the lower end, causing it to still further settle, and any considerable angle of inclination would be liable to cause the displacement of the vessel upon the blocks.

There was a boiler and engine and a group of pumps at the center of each side of the dock. The pumps all drew their water from a central well or compartment. This compartment was connected to the various other divisions of the dock by gates. The general plan of pumping was to start all the pumps and lower the level of the water in the pumping compartment, and then to open the gates from the end compartment and allow the water to flow by gravity to the pumping compartment. This, you will readily understand, would work out properly if the dock was always on a perfectly level keel, but if for any reason one end became lower than the other, the delivery of water from that end would not be as rapid, and the subsequent pumping would tend to increase the difficulty, and the only method of correcting this condition would be to stop pumping, close all gates and admit water from the outside of the dock to the high end or side, and then commence pumping over again.

It was soon discovered that the only possible way to handle



PARTIAL SIDE VIEW OF DREADNOUGHT, SHOWING LOCATION OF HEAVY GUNS.
(Photograph, Cribb, Southsea.)

The old balance dock now in use in the Erie Basin, is, I think, the oldest dock now in use in the harbor. As originally built, it had gates at each end similar to those referred to in previous section on the Adamson dock, from which it was undoubtedly an outgrowth, and, so far as I am able to learn, the builders believed that they would be able to operate it entirely as a floating structure without resting upon the bottom at any time.

The operation of this dock was intended to be as follows: The gates at one or both ends were opened, and water was admitted into the body of the dock, and it was sunk low enough for the vessel to be moved in; after the vessel was in place the gates were closed at both ends and pumping commenced, the idea being to remove the water between the side walls and end gates, but, as there were no divisions either longitudinally or laterally, to confine the water, as soon as pumping was commenced the water would flow to the lowest end or side, and it was found impossible to keep the dock and vessel in a horizontal position. The gates were then abandoned and the attempt made to operate the dock as a box or balance dock, and in this connection I wish to call your attention especially to the arrangement of the pumping machinery.

this dock was to place the vessel, whatever her length, in the center of the dock, and then to pump all compartments at the same rate, stopping to correct any tendency to roll as soon as it became apparent. The continual docking of vessels shorter than the total length of the dock has resulted in straining the dock to such an extent that the center of the dock, longitudinally, is now about 4 feet lower than the ends. The dimensions of this dock, 300 feet long by 100 feet wide, in a single structure, are such that it has never been possible to entirely remove it from the water, and it is certainly remarkable that after more than 50 years it is still possible to dock vessels upon it.

In the next development, which is the small sectional dock, commonly so called, the sections were made small enough to be controlled in sinking by locking logs connecting them; when a vessel is in place the vessel itself serves as the connection between the sections to steady and maintain them in correct relative position. The sections of this type of dock were made about 20 feet in the direction corresponding to the length of the dock, and of a width proportionate to the length of the dock, so as to give working room on each side of the largest vessel the dock would take. The machinery was placed on one side of the dock,

with a water connection or leader extending through the center bulkhead to the other side.

As this was the first type of floating dock to be extensively used, and as it embodies most of the principles that are in use in the more recent and larger docks, I will try and explain the method of pumping and handling somewhat in detail. It was a dock of five sections, which was quite a common number; these represent a dock, each section of which is about 20 feet long by about 60 feet wide. You will understand that we speak of the shorter dimension of the section (20 feet) as the length, because it is that dimension which forms part of the longitudinal dimension of the dock as a whole. Each section was divided at a point corresponding to the center line of the dock by a watertight bulkhead. At the extreme outside of each section there was a flood gate.

The pumping machinery was located on one side of the dock, and as it was necessary to bring the water from the other side beyond the center bulkhead, a leader or pipe was provided, the flow through which was controlled by a gate or valve similar to the flood gates. The pumping machinery consisted of four single acting pumps for each section, and were operated through rocker arms, connecting rods and shafting. To allow for movement between sections, the connection of the power from one section to the next was made by a combined double universal and slip joint. This mechanism permitted a considerable movement in any direction without interfering with the transmission of the power.

To limit the movement of the sections, there was provided on each side, at the junction of the wings with the deck, a continuous locking log, which passed through strong keepers near each end of each section. These logs were not intended to take any of the strain of lifting the vessel, but were to control and keep in alinement the sections while being lowered, and until the vessel was firmly resting upon the blocks, when it will be readily understood that the vessel herself would make a firm and strong bond between the sections. Power was furnished for pumping by a boiler and engine located on the middle section.

The operation of the dock is about as follows. The keel and bilge blocks having been prepared for the vessel to be docked, all the flood gates are opened about half way and the entering water causes the dock to settle; any tendency for one section or part of the dock to descend faster than the other is corrected by slightly closing the corresponding gate. When the deck of the dock approaches the surface the gates are gradually closed, and, as the water floods the dock between the wings, the different sections and the dock as a whole are carefully leveled.

This is quite important, to insure complete control of the dock. When the deck is entirely submerged, the flood gates are opened wider and the dock descends to the necessary depth to allow the vessel to enter over the blocks. At this depth all valves are closed, and the vessel is moved and correctly located over the blocking and secured by lines at bow and stern to the sides or wings of the dock. The pumping machinery is then operated, slowly at first, to bring the keel blocks gently against the keel of the vessel without disturbing them. As soon as the dock is pressed firmly against the bottom of the vessel the bilge blocks are drawn under the bilges. This may be done while the pumping is going on slowly, or, if the vessel is large, the pumping is stopped while the blocks are drawn. When this is accomplished, the pumping machinery is speeded up and the water removed more rapidly.

The dockmaster in the meantime watches the dock and vessel, and if for any cause there is a tendency for one side or end of the dock to rise faster than the other, he does not change the rate of pumping, but causes water to be let into the section or side which is coming up faster than the other. Of course, if the vessel is not as long as the dock, or does not rest evenly upon all the sections, those not supporting the vessel will naturally rise faster than those that are to support the vessel, and from the beginning of the pumping it will be necessary to check their rise by admitting water.

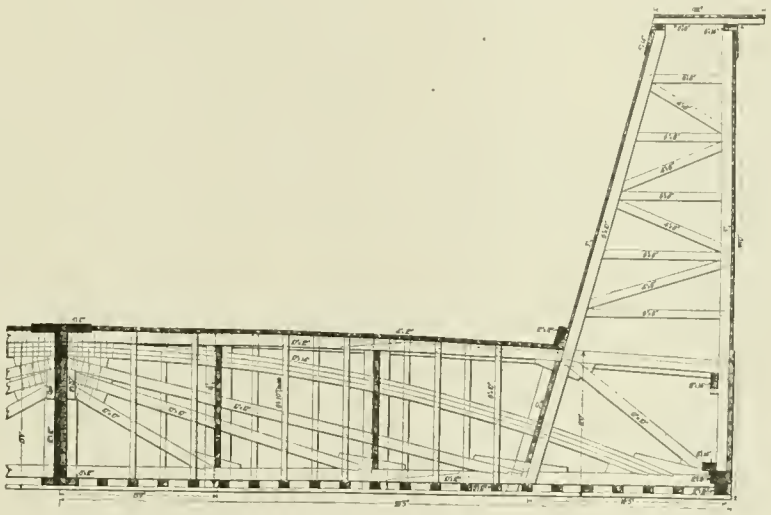


FIG. 7.—TRANSVERSE SECTION OF WOODEN DRY-DOCK, SHOWING TRUSS.

When the pumping commenced, the level of the water in the interior dock was approximately that upon the outside, and consequently the pumping machinery would be required to deliver the water only at a slight elevation above that from which it was received, and the load upon the engine at this time is small, but at this time the water is being removed from the wings only, and as the area or bulk of these wings (exclusive of the pump wells, which do not assist, as they are full of water at all times while the dock is submerged) is small comparatively to the area or bulk of the vessel at the water line, the vessel rises slowly, while the difference between the inside and outside level of the water in the dock changes rapidly, thus increasing the load upon the pumping plant. This will continue until the interior level of the water (that in the interior of the dock) has been lowered down to the level of the deck. At this time, such a dock as the one referred to, with a vessel of the full capacity of the dock upon it, drawing when afloat, say, 12 feet, will have been lifted 3 feet, and the interior water level, which at the start was about 2 feet below the exterior, has been increased to a difference of 12 feet.

When the interior water level reaches the level of the deck of the dock, a very marked change takes place in the conditions. The area to be pumped at once increases to the entire area of

the dock and is many times more than the corresponding area of the vessel, which, in fact, is rapidly decreasing. The necessary consequence is that the vessel and dock from this time on rise out of the water much faster than the reduction of the interior water level, and the head against which the pumps are required to deliver the water rapidly falls with a corresponding decrease of the load on the engine. If we consider this dock as having a depth in the body of 8 feet and that at the time the deck of the dock reaches the water there is 1 foot of water remaining in the dock, then the head against which the pumps will be delivering at this time will be 7 feet, a decrease of almost one-half from the maximum head of 12 feet.

With the deck of the dock at the surface of the water another marked change takes place. If the vessel being raised has occupied only four sections, the fifth section will now have in it about 7 feet of water, or the flood gates of this section have been so regulated that the interior water level is only 1 foot below the exterior, but from this point, or, as we say, when the water leaves the deck of the dock, it is necessary to pump all sections, both loaded and unloaded alike.

The lack of comprehension and grasp of the principles of hydraulics as applicable to these structures has resulted in a general mistrust which is not warranted. With the deck of the dock flush with the surface of the water, I would like to call your attention to some of the considerations of stability of dock and vessel.

As you are well aware, a vessel when afloat without cargo (which is the usual case when dry docking is to be done) is in a condition of minimum stability, and this stability will rapidly disappear as the vessel is raised from the water. Therefore it is necessary in dry docking a vessel in a floating dry dock to make some provision for the stability of dock and vessel as they rise together out of the water. The stability of the vessel relative to the dock is provided for by the bilge blocks, which are drawn under the bilges (corresponding to the widest part of the bottom of the ship) before she is lifted any considerable distance, but as soon as this is done the dry dock must assume the double responsibility of caring for itself and the vessel also. The wings of a floating dry dock are often considered as serving only to carry the pumping machinery, but this is far from the fact. Their most important use is to furnish stability for the vessel and dock as they rise out of the water.

The details of this problem are too intricate and involved to be considered at this time, but if you will consider the fact that stability in its last analysis depends upon turning moment applied to the floating mass, you will at once see that the wings of a floating dock, situated at a considerable distance from the center line of the dock and vessel considered as a single floating structure, are admirably placed to counteract the loss of stability of the vessel as she rises out of the water. Further than that I would state that the proportions are such in a properly designed dock that the combined stability of dock and vessel are at all times more than the stability of the vessel when afloat.

From the consideration of this dock we will pass to the next development, or the "box or balanced dock," as illustrated by Fig. 3. As has been previously stated, this dock is the type which is the most popular at this time for small and moderate sizes, or from 500 to 3,000 tons capacity.

The special features of construction of this dock are a single rigid structure, a center longitudinal watertight bulkhead, and a number of watertight transverse bulkheads dividing the dock into a sufficient number of separate compartments so that the controllable pumping may control the action of the dock. The machinery of these docks is located on one side only, and the water from the opposite side is secured by leaders and control valves in the same manner as described for the sectional docks. The flooding and sinking of the dock is also carried out in the same manner, care being taken in sinking to have the water come over the deck at each end slowly, and as evenly as possible. The vessel, when smaller than the capacity of the dock, should always be located near one end, and the pumping regulated by the flood gates so as to bring up the dock on an even keel, both transversely and longitudinally.

As to the particular construction of one of these docks, a cross-section of a recently designed dock of about 1,500 tons capacity, shows a width of 68 feet and the depth at the center corresponding to the longitudinal center line is 10 feet 8 inches, and the entire depth, including the wing, is 32 feet 11 inches. The distribution and dimensions of the timber need little explanation, a second longitudinal bulkhead being added on each side of the center to give longitudinal rigidity. There are twenty pumps, located in three pump wells on one side of the dock. On the opposite side are three similar pump wells, but without pumps. The object of these pump wells is to equalize the buoyancy on each side of the dock, as the pump well space does not assist in lifting. The construction of the prow or outrigger on each end shows an opening in its center, to allow for the lowering of the rudder of a vessel when on the dock.

We will now pass to the most recent type of floating dry dock, illustrating the largest development in the commercial floating dock in this country up to the present time. (See Fig. 4.)

This shows a balanced sectional dry dock of five sections, having an over all length of 468 feet, a width of 110 feet 10 inches, and a lifting capacity of 10,000 tons. The arrangement of sections, locking logs, bulkheads and pumping machinery is clearly shown. There are thirty pumps on each side, and the manner in which they are operated is quite clearly shown.

This type of dock is the invention of Mr. Frederic C. Lang, and patents were issued to him under dates of April 10 and August 21, 1900. As we have followed the developments of these structures, it will seem to most of you that this dock is so much a development out of the previous structures that its production called for little invention, but this view is opposed to the most positive evidence to the effect that there was a real and well-known demand for a large floating dock in this port for more than twenty years. In fact, the two Dodge-Burgess docks, of 3,000 and 3,500 tons, previously referred to, were the largest in existence in this country, and no actual advance had been made in fifty years.

Much of the unqualified success of the undertaking, even from a 10,000-ton floating dry dock was first brought to the attention of the engineering firm with which I was connected (Faber du Faur & Donnelly), and I became convinced that in connection with the development of an entirely new plan of construction an increase of size of about three times over any previous wooden floating dry dock was to be undertaken, you will readily understand that the situation called for serious thinking, particularly as the next largest work in this line was about fifty years old.

Much of the unqualified success of the undertaking, even from an engineering point of view, is due to the inventor, Mr. Lang, and his long experience in the building and operating of the different types of smaller docks; from years of experience in handling them as a dockmaster he was in possession of a knowledge of all the conditions which such a structure must meet. During the designing, one of the first features which received consideration was the relative advantage of wood and steel construction. After a careful investigation, somewhat to my surprise, I am free to admit, wood won out upon its merits, and when the reduction of first cost is also made an element, the comparison becomes impossible, as the cost of a steel dock of this size is almost, if not quite, twice as much as one of wood. As to durability, it would seem as if little could be asked in that direction, with the evidence before us of the three largest floating docks in the port, each of which is about fifty years of age. Some one may ask if the original wood of these docks has not been replaced, perhaps several times, in that period. To this I would answer that the most careful investigation on my part has failed to discover any evidence of any such change of timber in

the body of the dock, or the trusses which support the weight of the ship. In the upper work, which has been exposed to the sun and weather, there has been considerable replacing of material.

To protect these wooden structures below water from the attacks of worms and the teredo, it is the practice to treat the bottom and sides with a coat of coal tar, then sheath them with hair felt saturated with creosote, and this with a covering of 1-inch rough boards treated with creosote and arsenic. A dock prepared in this manner may remain in the water almost indefinitely.

The length of the trusses was 110 feet and the depth 12 feet 2 inches. The upper and lower members of the truss passed through the center bulkhead, and the longer diagonal braces met in the center. The shorter braces abutted against the center bulkhead on opposite sides. The center bulkhead was watertight, as previously described; on each side there were three additional bulkheads to stiffen the dock longitudinally. These were not made watertight. The members of the truss were proportioned for a maximum strain of 1,000 pounds per square inch, tension and compression.

The distribution of the strains in a dock of this kind are somewhat peculiar. The first pumping removes water only from the wings located at each end of the trusses, and, with the vessel resting only on the keel blocks at the center of the dock, we have a beam loaded at the center and the force applied at the ends.

When the vessel is entirely raised, the wings not only do not support any of the burden, but themselves act as a reverse load upon the trusses and the weight of the ship is almost entirely borne by that portion of the trusses between the wings. Careful investigation of these conditions develops the curious fact that under some conditions of use the greater strain upon the trusses will be produced by a part of the vessel's weight acting through the buoyancy of the wings upon the ends of the trusses.

The pumps were arranged in groups as shown in Fig. 4. The pump well has a watertight floor at about the level of the deck of the dock, and a spillway is provided through the outer wall. The pumps are square wooden boxes extending through the floor of the pump well, and to within a few inches of the bottom of the dock. Near the bottom of the pump barrel, which is 16 inches square, is the foot or suction valve. About half way up the pump well there is a rocker arm, to each end of which is attached a pump rod and to one end of which the connecting rod is attached, and delivers the motion from the line shaft above; the stroke of the pumps is 20 inches, and as they are single acting, they each deliver about 2 cubic feet of water per revolution. They operate at from 60 to 75 revolutions per minute.

The pumping machinery on each side of the dock is operated by a vertical slide valve engine having a cylinder 20 inches in diameter by 24 inches stroke. There was no attempt in the power equipment to obtain high economy, as at the most they would operate but one or two hours a day. There are two upright boilers on each side, having a diameter of 72 inches and a height of 13 feet, built for a working pressure of 125 pounds per square inch. A pressure of from 80 to 90 pounds is found to be all that is required to operate the dock.

The construction of floating docks, and their development up to this time, have been almost entirely in the hands of practical men, and the details of their construction and equipment have been quite thoroughly worked out, but the hydraulic principles involved and the structural strains involved in their use have received little attention, and are not generally understood.

ABSTRACTS FROM DISCUSSION.

All drift-bolts were of galvanized iron; on the extreme upper work, which is always above the water and can be frequently painted, black screw-bolts were used. In the design, particularly the parts below the water, the study was to use as few screw-bolts as possible. The only long screw-bolts are 1¼ inches diameter through the main trusses alongside of the longitudinal bulkheads; these were galvanized. When metal such as drift-bolts is entirely in wood it will not deteriorate, but when used as through bolts it will rust in time, even when galvanized.

Nearly all iron vessels carry a docking plan and generally have a straight keel, but wooden vessels are sometimes very much out of shape. We have docked a side-wheel steamer used as a towboat on the Hudson river, the keel of which was 2½ feet out of a straight line. This boat was built straight and had sagged to a double curve, the keel being down 2½ feet in the center below the highest place, which was about two-thirds of the way from the center to the end. The ends dropped a foot below the highest point. In blocking for a vessel such as this we use patent keel blocks, that is, blocks composed of wedges that can be drawn in such a way as to be adjusted while the vessel is in place in the dock. Every fourth block is usually made a patent or adjustable block, and when docking a vessel, the shape of which is in doubt, we arrange the blocking in a straight line, and then as soon as the vessel touches the blocks we haul on the patent blocks. If the keel is straight, none of the blocks can be moved, as they will all be in touch with the bottom. If it is not straight, all will be hauled until they touch the keel. Then the vessel will be taken out of the dock and it will be pumped up, when the shape of the keel will be clearly shown by the patent blocks, and the intermediate blocks can all be built up to correspond, after which the vessel can be docked in the usual way.

The object of the arch form of truss is to get a good hold of the lower truss head; if you carry a straight member out to that point, you will get very little actual connections coming in at such an acute angle, but by bringing the arch over we get a very good connection at that point, which takes the load off the wings when the dock is up; when there is nothing on but the ballast that is used to sink the dock. In the 10,000-ton dock we have to put in 500 tons of ballast to each section, or 2,500 tons of ballast. When the dock is pumped up we have then a great bulk of stone piled in each wing and the dock is supported by a uniform pressure of water across the entire bottom. The center of that force will be at the center line; we have the weight of the structure and 500 tons on each side tending to break the dock in two in a reverse direction.

I have considered the one-piece dock and it seems to me that if you undertake to make a structure 800 or 1,000 feet long, and endeavor to keep the depth of the bottom down to a reasonable figure, say 20 feet, the proportion of length to depth in the truss is such as to call for an enormous cross-section of metal, if you are to keep the deflection down to a reasonable figure. I am of the opinion that the problem can be satisfactorily solved in all its requirements by a sectional dock.

Speaking of a commercial dock, you must come right down to the question whether it will pay or not: it isn't a matter of the largest dock in New York harbor. This dock has been a commercial success simply because it is built small enough. It will dock a vessel 525 feet long; that doesn't go into the largest class, of which there are only a few vessels. As the vessel gets larger it has more compartments; those vessels can hobble over to the other side, where they have basin docks. A very few exceedingly large docks will do for the largest vessels, and it is hardly reasonable for us to make them here, if they have them on the other side. The question is, if you have your large dock here, will the vessel stay here? Not unless she absolutely has to.

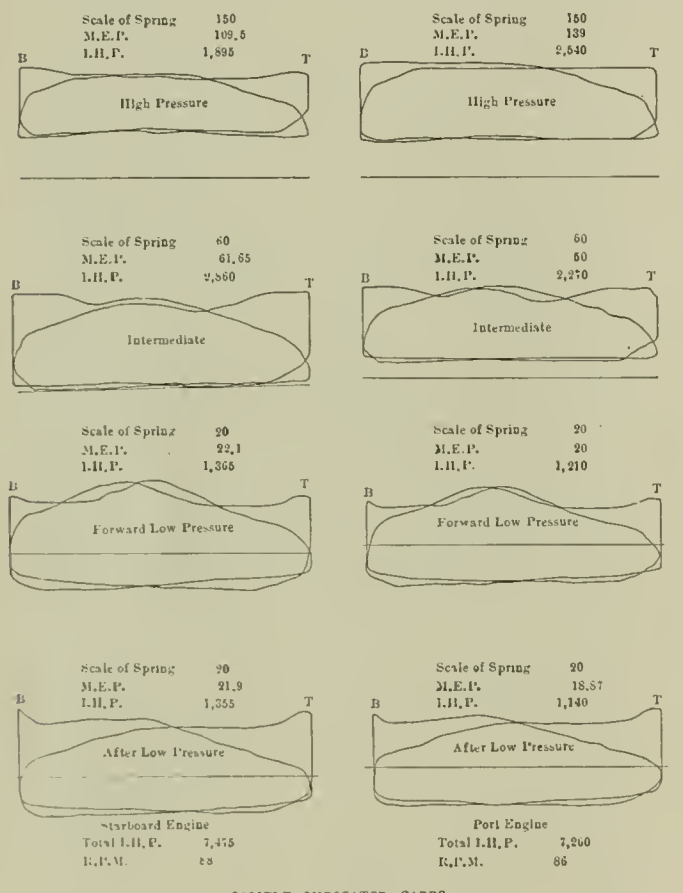
The Mallory Line of coastwise steamships, plying between New York and Brunswick, Ga., Key West, Mobile and Galveston, has been sold to Charles W. Morse for a consideration said to be $7,500,000. The ships of the line are *San Jacinto*, 6,069 tons; *Denver*, 4,579; *Concho*, 3,724; *Sabine* and *Nueces*, 3,350 each; *Comal*, *Lampassas* and *Alamo*, 2,940 each; *San Marcos* and *Colorado*, 2,800 each, and *Rio Grande*, 2,566. A new steamer is now being built at Newport News, and two others are to be added.

DOCK TRIAL OF THE UNITED STATES BATTLESHIP MINNESOTA.

BY H. B. GREGORY.

The United States battleship *Minnesota,* the fifth 16,000-ton batteship for the navy, was given her dock trial at the yard of her builders, the Newport News Shipbuilding and Dry Dock Company, August 14 to 17 inclusive.

Each engine was run separately on two consecutive days. The trial started with the port engine on August 14 and 15, followed by the starboard engine on the 16th and 17th. The first day's run, in each case, was of about eleven hours' duration. Four boilers were used, and the maximum revolutions attained were 68.7 for the port and 66 for the starboard engine. On the second day's run of each engine, the power developed was largely in-



SAMPLE INDICATOR CARDS.

creased. Six boilers were in operation, and the maximum revolutions reached 86 and 89, respectively, port and starboard. The port engine was in operation about ten and one-half hours on this day, while the starboard engine on the corresponding day was run only about five and one-half hours, thus making the total running time about twenty-one and one-half hours and sixteen and one-half hours respectively.

The boilers used each day were so chosen that each one was in operation for at least one day's run, and in this way each unit of the boiler plant received a practical test. The firing was systematic, the periods of firing and raking being regulated by electric signal operating automatically at equal intervals. The blowers were run throughout the trial at an average of about 350 revolutions, showing a slight fraction of an inch air pressure, but the fire rooms were not strictly closed.

Everything in the machinery plant worked admirably, and the results of the trial were most pleasing and satisfactory in every way, giving good grounds to expect successful speed results, when the official preliminary trial is run.

The following are the principal dimensions of the vessel and machinery, and the trial data:

HULL DIMENSIONS.

Length between perpendiculars	450 feet 0 inches
Length over all	456 feet 4 inches
Beam, extreme	76 feet 10 inches
Draft, normal	24 feet 6 inches
Displacement, normal	15,970 tons
Designed speed at normal displacement	18 knots

ENGINE DATA.

Type, four-cylinder triple expansion:	
Number	2
H. P. cylinder, diameter	32½ inches
I. P. cylinder, diameter	53 inches
L. P. cylinders (two), diameter, each	61 inches
Stroke	48 inches
Designed indicated horsepower	16,500
Designed steam pressure at high-pressure cylinder	250
Revolutions per minute, designed	120

BOILER DATA.

Type	Babcock & Wilcox
Number	12
Heating surface, square feet	52,752
Grate surface, square feet	1,100
Ratio, G. S. to H. S.	1 to 47.96
Steam pressure	265

SYNOPSIS OF TRIAL.

	Port.	Starb'd.
Steam pressure at boilers, gage	260	250
Steam pressure at engine, gage	255	240
Steam pressure at H. P. steam chest, gage	245	240
Steam pressure at 1st receiver, absolute	90	98
Steam pressure at 2d receiver, absolute	20	22
Vacuum in inches	23	26
Revolutions per minute	86	88
Mean effective pressure, H. P. Cyl.	139	109.5
Mean effective pressure, I. P. Cyl.	50	61.65
Mean effective pressure, F. L. P. Cyl.	20	22.1
Mean effective pressure, A. L. P. Cyl.	18.87	21.9
Mean effective pressure, aggregate referred to low-pressure cylinders	59.5	59.9
Indicated horsepower, H. P. Cyl.	2,640	1,895
Indicated horsepower, I. P. Cyl.	2,270	2,860
Indicated horsepower, F. L. P. Cyl.	1,210	1,365
Indicated horsepower, A. L. P. Cyl.	1,140	1,355
Indicated horsepower, total	7,260	7,475
Indicated horsepower, total both engines	14,735	

TEMPERATURES, F°.

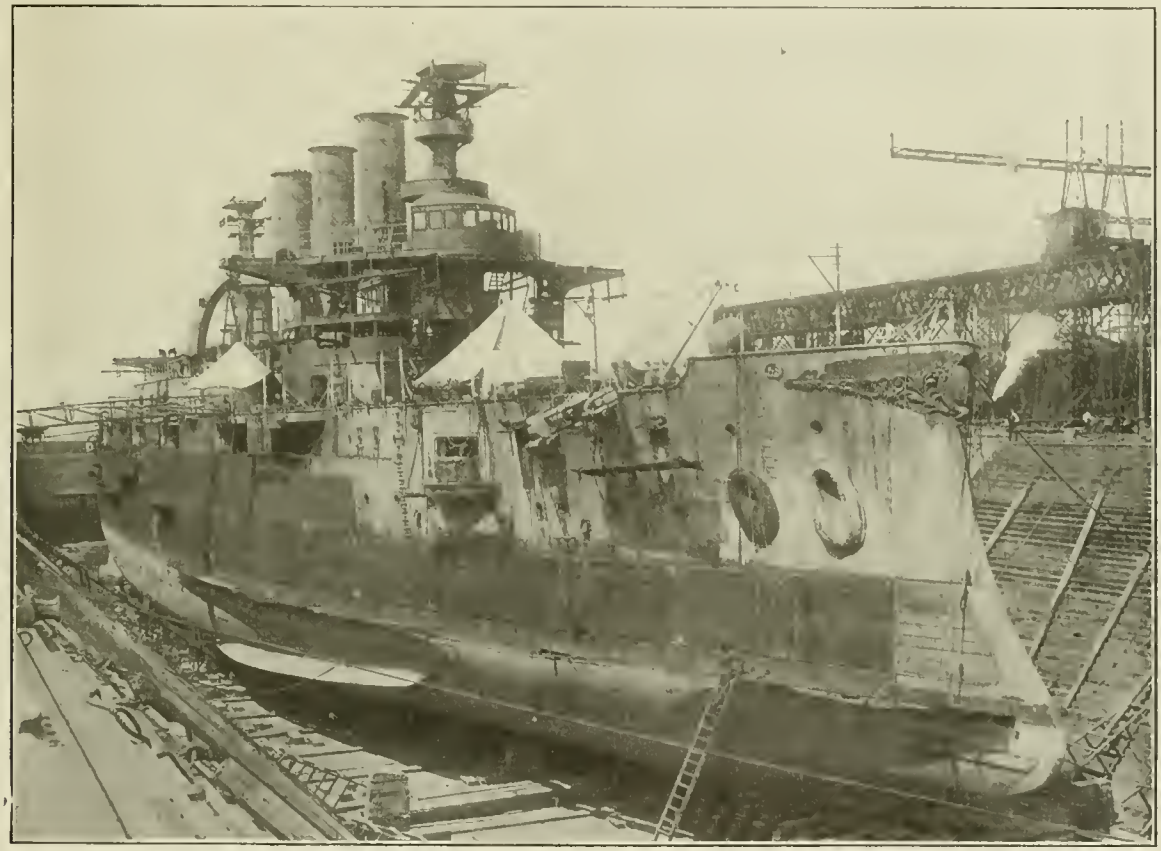
Engine room, working platform	87 to 128
Engine room, lower grating	99 to 109
Engine room, upper grating	103 to 130
Fire room, working level	102 to 141
Fire room, grating	96 to 135
Fire room, at blowers	121 to 150
Main injection	78 to 93
Outboard delivery	109 to 127
Feed tank	91 to 120
Main feed	174 to 204

Benjamin H. Warren, of the firm of Kafer, Mattice & Warren, 60 Wall street, New York City, died suddenly October 19. Mr. Warren was graduated from the Naval Academy in 1874, and after four years of service entered commercial life, his work culminating with the presidency of the Allis-Chalmers Company. He is the second of the new firm above mentioned to die during the short time which that firm has been in existence, Mr. Kafer having passed away a few weeks after the firm was organized.

CLEARANCE AND RECEIVER DROP IN THE DESIGN OF COMPOUND ENGINES.

BY P. F. WALKER.

It seems to be the general practice of writers on the subject of engine designing when dealing with compound engines, to omit consideration of clearance altogether and to deal with drop or pressure between cylinders in a manner more or less indirect or vague. For accurate designing, and especially for a correct determination of the point of cutoff in the low-pressure cylinder, it is necessary to take both of these conditions into account. In the numerical calculations to follow in this paper, the writer has not striven particularly for the best proportions, nor does he expect that all losses have been corrected in the best possible degree of accuracy, but the object has been to outline a rational method of dealing directly with the quantities mentioned. The question of distribution of the work between the cylinders has not been considered at all, but in the case cited the common proportion assumed between the piston areas provides for a nearly equal division.



THE BATTLESHIP MINNESOTA IN DRY DOCK AT NEWPORT NEWS.

The method of dealing with drop between cylinders will be readily understood from the regular course of the discussion, but the treatment of clearance may need some preliminary explanation. The following is the common discussion as given in steam engine texts.

Considering the theoretical indicator card of a simple engine, as in Fig. 1, let

V_1 = the volume swept through by the piston during its stroke up to the point of cutoff.

V_2 = the entire volume of piston displacement.

V_c = the volume of the clearance space.

P_1 = absolute pressure of the entering steam.

P_2 = absolute pressure of steam at the end of expansion.

P_b = absolute back pressure of steam.

Then $V_1 + V_c$ = total volume of steam in the cylinder at cutoff.

$V_2 + V_c$ = total volume of steam at end of stroke.

and $\dfrac{V_2 + V_c}{V_1 + V_c}$ = the true ratio of expansion.

This ratio is seen to be less than $\dfrac{V_2}{V_1}$, which is the reciprocal of the fractional portion of the stroke traversed by the piston at cutoff, and which is the ratio of expansion when clearance is neglected.

If the expansion be assumed to be according to the rectangular hyperbola, so that PV = constant, the value of P_2 will be found from the equation

$$P_1 (V_1 + V_c) = P_2 (V_2 + V_c),$$

from which

$$P_2 = P_1 \frac{V_1 + V_c}{V_2 + V_c}$$

This value of P_2 is greater than $P_1 \times \dfrac{V_1}{V_2}$ which is the expression that results when clearance is neglected, and hence it follows that the presence of a clearance volume serves to raise the expansion line, and thus to increase the power of the engine. That this increase of power is accompanied by increased wastes of heat energy does not concern us in the present discussion. The main point is that if the engine is designed for a certain power without regard to clearance, proper allowances being made for the reduction of mean effective pressure due to losses from cylinder condensation, wire-drawing, etc., it will, when constructed with the necessary clearance spaces, develop more than the rated power; and the fact is to be recognized that it is as much a fault to produce engines of too great power as of too small power.

The work done during one stroke of the piston is represented on the indicator card by the area *a b c e f d a*. Work is the product of a force times a distance, and on the indicator card the vertical dimension represents the force and the horizontal dimension the distance. As actually drawn, the vertical dimension

is in terms of pounds pressure per square inch, which may be expressed in terms of total force on the piston by multiplying by the area of the piston; while the horizontal dimension represents the length of stroke on a reduced scale. If, however, the factor of piston area be multiplied into the length of stroke, the result is the volume of piston displacement, and the final product of force times distance thus reduces to the product of pressure per unit area times the volume through which that pressure acts. For convenience, the pressures will be kept in terms of pounds per square inch, which means that 144 times the true volume in cubic feet will be taken for the horizontal dimension, this being the result of multiplying piston area in square inches by length of stroke in feet. In engine designing, however, the cylinder dimensions are unknown quantities, and the mean effective pressure is the only quantity involved on the assumed indicator card, so that any convenient values may be assigned to the terms V_1 and V_2, so long as they give the true ratio of expansion that has been selected as the proper one for the conditions. The mean effective pressure will then be found by dividing the effective area of the card by the effective length, V_2.

Since pressures are best measured from the zero line, the effective area of the card is best found from the combination of the three portions, as follows:

Effective area $= (a\ b\ c\ e\ f\ d\ a) = (g\ b\ c\ h) + (h\ c\ e\ k) - (a\ f\ k\ g)$.

It is readily shown by the principles of the calculus that the area under a curve whose equation is $PV =$ constant, between volume limits of V_a and V_b, pressures being measured from the zero or vacuum line, is,—

$$\text{Area} = PV \times \text{hyp. log.} \frac{V_b}{V_a}$$

We have then the following expressions for the three portions of the card above mentioned,—

$$\text{Area } (g\ b\ c\ h) = P_1 \times V_1$$
$$\text{Area } (h\ c\ e\ k) = P_1 (V_1 + V_c) \times \text{hyp. log.} \frac{V_2 + V_c}{V_1 + V_c}$$
$$\text{Area } (a\ f\ k\ g) = P_b V_2.$$

From these there results as the value of the mean effective pressure on the theoretical card,

$$\text{m. e. p.} = \frac{P_1 V_1 + P_1 (V_1 + V_c) \times \text{hyp. log.} \frac{V_2 + V_c}{V_1 + V_c} - P_b V_2}{V_2} \quad (1)$$

This is the true mean effective pressure for the perfect engine, and will be thus referred to later.

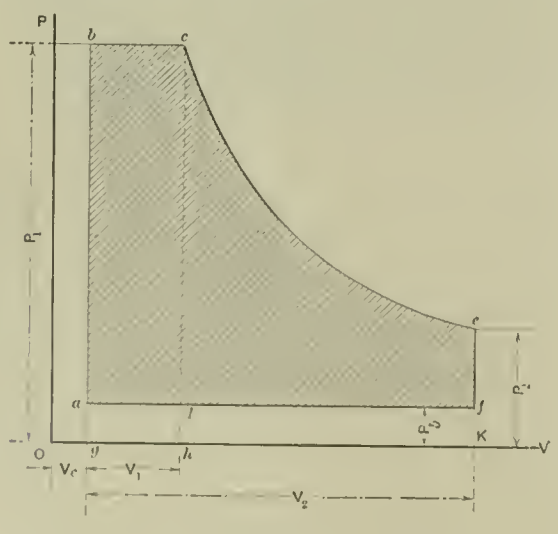


FIG. 1.

When the clearance volume is neglected altogether, this equation reduces to the form,

$$\text{m. e. p.} = \frac{P_1 V_1 + P_1 V_1 \times \text{hyp. log.} \frac{V_2}{V_1} - P_b V_2}{V_2}$$
$$= P_1 \left(\frac{V_1}{V_2} + \frac{V_1}{V_2} \times \text{hyp. log.} \frac{V_2}{V_1}\right) - P_b$$

But $\frac{V_2}{V_1}$ = ratio of expansion $= r$, when clearance is neglected.

$$\text{Hence m. e. p.} = P_1 \left(\frac{1 + \text{hyp. log. } r}{r}\right) - P_b \quad \ldots\ldots\ldots\ldots (2)$$

This is the form of equation ordinarily used in engine designing, the ratio of expansion being considered simply as the reciprocal of the fraction of stroke traversed by the piston at cutoff.

Another expression that is sometimes used results from considering clearance in the same manner as in equation (1), but the m. e. p. is calculated as though the piston swept through the clearance volume in addition to the piston displacement proper. Equation (1) then becomes,

$$\text{m. e. p.} = \frac{P_1 (V_1 + V_c) + P_1 (V_1 + V_c) \times \text{hyp. log.} \frac{V_2 + V_c}{V_1 + V_c} - P_b (V_2 + V_c)}{V_2 + V_c}$$

Since $\frac{V_2 + V_c}{V_1 + V_c}$ is in this case the ratio of expansion, r, this becomes,

$$\text{m. e. p.} = P_1 \left(\frac{1 + \text{hyp. log. } r}{r}\right) - P_b \quad \ldots\ldots\ldots\ldots\ldots\ldots (3)$$

This is identical in form with equation (2), but r here represents the true ratio of expansion. The error involved in assuming the longer stroke of piston is considerable, however, giving too great a value to the mean effective pressure.

A numerical example will show the differences between these three equations clearly. Take the case of a steam engine using steam at 125 pounds per square inch absolute pressure, cutting off at one-fourth stroke, with back pressure 18 pounds per square inch, and with 5 percent clearance. Since the actual size of the engine is independent of the pressures, we may for present purposes put V_1 equal to unity and V_2 equal to 4, while V_c equals 5 percent of 4, or 0.2 cubic foot.

$$\text{From (1), m. e. p.} = \frac{125 \times 1 + 125\ (1 + .2) \times \text{hyp. log.} \frac{4.2}{1.2}}{4} - 18 \times 4$$
$$= 60.22 \text{ pounds per square inch.}$$

This is the true theoretical mean effective pressure.

$$\text{From (2), m. e. p.} = 125 \left(\frac{1 + \text{log. } 4}{4}\right) - 18.$$
$$= 56.58 \text{ pounds per square inch.}$$

$$\text{From (3), m. e. p.} = 125 \left(\frac{1 + \text{log.} \frac{4.2}{1.2}}{\left(\frac{4.2}{1.2}\right)}\right) - 18$$
$$= 62.47 \text{ pounds per square inch.}$$

To disregard clearance in designing is here seen to result in a theoretical mean effective pressure too small by 6.1 percent, and to consider it only to the extent of determining the true ratio of expansion without changing the form of the expression for mean effective pressure to that in equation (1), makes that quantity too large by 3.7 percent. By doing the small amount of additional work required in equation (1), a value is found that has been corrected for one of the variables usually entering into the uncertainties of engine designing. This is especially desirable when engines differing materially in the percentages of clearance are being compared

In the accompanying table values of the ratios of expansion and of a factor for the rapid determination of the true mean

effective pressure, according to equation (1), are given for varying values of clearance and points of cutoff.

With the foregoing principles established, we may proceed to the method of designing compound engines, and for the sake of greater clearness numerical quantities will be used.

Let it be required to design a compound engine condensing, to develop 500 indicated horsepower, with steam at 140 pounds per square inch absolute pressure at the high-pressure steam chest, and with a mean piston speed of 600 feet per minute. The total number of expansions will be taken as 16*, giving a theoretical terminal pressure in the low-pressure cylinder of $140 \div 16 = 8.75$ pounds per square inch, absolute. Back pressure in the low-pressure cylinder will be taken as 3 pounds per square inch, the ratio of cylinder volumes 1 to 4, and the clearance 5 percent of the piston displacement in each cylinder. Drop from the high-pressure cylinder into the receiver will be taken as 8 pounds, and a further drop of pressure before the steam enters the low-pressure cylinder of 4 pounds will be allowed for. This determines the initial steam pressure for the low-pressure cylinder.

The theoretical indicator card may first be drawn as in Fig. 2, on which the values are designated as follows:

V_1 = volume of piston displacement in the high-pressure cylinder.

V_2 = volume of piston displacement in the low-pressure cylinder.

v_1 = volume of clearance in the high-pressure cylinder.

v_2 = volume of clearance in the low-pressure cylinder.

X_1 = percent of stroke traversed by the piston at cutoff in high-pressure cylinder.

X_2 = percent of stroke traversed by the piston at cutoff in low-pressure cylinder.

The total volume of the low pressure cylinder, including clearance, must be 16 times the volume of steam in the high-pressure cylinder at the point of cutoff, which initial volume must include the high-pressure clearance. These two volumes may thus be represented by 16 and 1, respectively. Also, since a cylinder ratio of 1 to 4 has been assumed, with the percentage of clearance the same in both cylinders, the total volume of the high-pressure cylinder including clearance will be one-fourth of 16, or 4. The number of expansions in the high-pressure cylinder will thus be 4.

We now have:

$$V_2 + v_2 = V_2 + .05V_2 = 1.05\ V_2 = 16$$

Hence
$$V_2 = \frac{16}{1.05} = 15.24$$
$$v_2 = .05 \times 15.24 = 0.76$$
$$V_1 = \frac{15.24}{4} = 3.81$$
$$v_1 = .05 \times 3.81 = 0.19$$
$$X_1 = \frac{1 - v_1}{V_1} = \frac{1 - .19}{3.81} = 0.21 \text{ nearly,}$$

which gives the point of cutoff in the high-pressure cylinder.

P_2 = terminal pressure in high-pressure cylinder $= \frac{140}{4} = 35$ pounds per square inch.

P_{b_1} = back pressure in high-pressure cylinder $= 35 - 8 = 27$ pounds per square inch.

P_3 = initial pressure in low pressure cylinder $= 27 - 4 = 23$ pounds per square inch.

Since the steam which fills the high-pressure cylinder and its clearance space at 35 pounds pressure is to be contained in the low-pressure cylinder and clearance space at the point of cutoff at 23 pounds pressure, it is necessary to know the volume which the steam will occupy at the two pressures. These volumes will be inversely proportional to the densities at the two pressures, or directly as the specific volumes. From the steam tables, one pound of steam at 35 pounds pressure occupies 11.78 cubic feet, and at 23 pounds, 17.46 cubic feet.

Therefore, $\frac{X_2}{100} \times (V_2 + v_2) = \frac{17.46}{11.78}(V_1 + v_1)$

or, $\frac{X_2}{100} \times (15.24 + .76) = \frac{17.46}{11.78} \times 4$

whence, $X_2 = 33.9$ percent, nearly, which indicates the point of cutoff in the low-pressure cylinder.

The ratio of expansion in the low-pressure cylinder may now be found to be,

$$r_2 = \frac{V_2 + v_2}{\frac{X_2}{100}(V_2 + v_2)} = \frac{16}{.339 \times (15.24 + .76)} = 2.7.$$

Or, by ratio of pressures, $r_2 = \frac{P_3}{P_4} = \frac{23}{8.75} = 2.7$, nearly.

The theoretical mean effective pressures for both cylinders may now be calculated in the regular manner, from equation (1).

m. e. p. in high-pressure cylinder

$$= \frac{P_1 \times X_1 \times V_1 + P_1 (X_1 V_1 + v_1) \text{ hyp. log. } 4}{V_1} - P_b$$

$$= 140 \left(\frac{.21 \times 3.81 + (.21 \times 3.81 + .19) \log. 4}{3.81}\right) - 27$$

$= 53.36$ pounds per square inch.

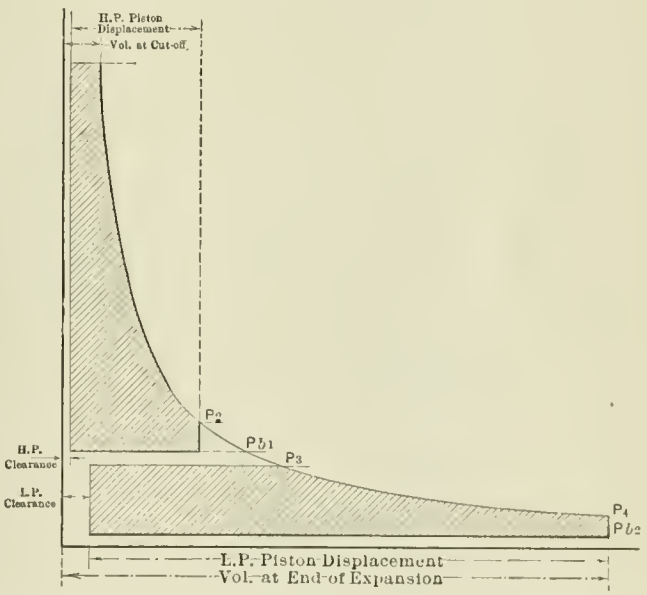


FIG. 2.

m. e. p. in low-pressure cylinder

$$= 23 \left(\frac{.339 \times 15.24 + (.339 \times 15.24 + .76) \log. 2.7}{15.24}\right) - .3$$

$= 13.68$ pounds per square inch.

The actual mean effective pressures that may be expected in the two cylinders are considerably smaller than these values. The factor to be used, which corresponds to the factor commonly employed in usual methods of design, and known as the card factor, must, of course, be decided upon after due consideration of all the conditions; but it is not in the scope of the present article to discuss that point. For the present instance it will be assumed that the same factor applies to both cylinders, and 80 percent will be used. Therefore we have for the expected mean effective pressures,

in the high-pressure cylinder, m. e. p. $= .80 \times 53.36 = 42.688$ pounds per square inch.

in the low-pressure cylinder, m. e. p. $= 0.80 \times 13.68 = 10.944$ pounds per square inch.

The m. e. p. of the low-pressure cylinder, referred to the high-pressure cylinder, will be $10.944 \times 4 = 43.776$ pounds per square inch.

*This is much higher than is commonly met in marine practice.—Ed.

Hence the total power of the engine will be divided between the cylinders in the ratio of 42.688 for high-pressure cylinder to 43.776 for low-pressure cylinder. Hence the power of the high-pressure cylinder is,

$$500 \frac{42.688}{(42.688 + 43.776)} = 247, \text{ and for}$$

the low-pressure cylinder $= 500 - 247 = 253$.

The power to be developed in each cylinder, the mean effective pressure, and the piston speed being thus determined, the diameters of the two cylinders may be calculated in the usual manner, with the equation,

$$\text{I. h. p.} = \frac{PLAN}{33{,}000}$$

wherein $L \times N =$ length of stroke times number of strokes per minute, is the mean piston speed. We have, therefore, for high-pressure cylinder,—

engine would be necessary, in order to use the method to best advantage, and this should be done for the high and low-pressure cylinders separately. With these values carefully selected good results may be expected.

The chief advantage of the system lies in the fact that the two cylinders are considered separately. This enables the designer to provide a steam distribution that will be best suited to the conditions of operation in each. Since the two cylinders are really independent engines connected to the same shaft, they are properly treated as such, and all of the features affecting economy of simple engines working with steam of the same pressures apply to them. Drop of pressure out of the high-pressure cylinder is thus desirable for the same reasons that make it inadvisable to run simple engines expanding to the back-pressure line, and it is desirable to treat this feature in a rational manner. Evidently by a continuation of the process triple and quadruple engines may be designed by the same method.

Ratios of expansion and factors for theoretical mean effective pressures in steam engines for varying points of cut-off and clearance volumes. Determined as follows :—

Let P_1 = initial pressure of steam.
P_b = back pressure on piston.
L = length of stroke.
l = distance traversed by piston at cut-off.
c = length of cylinder to equal clearance volume.

Then ratio of expansion $= r = \frac{L + c}{l + c}$

m. e. p. $= P_1 \left(\frac{l + (l + c) \text{ hyp. log. } r}{L}\right) - P_b$

Let $\left(\frac{l + (l + c) \text{ hyp. log. } r}{L}\right) = F$

Then theoretically m. e. p. $= (F \times P_1) - P_b$

VALUES OF F AND r.

Cut off	Clearance in percent of piston displacement.																			
	2%		2.5%		3%		4%		5%		6%		7%		8%		9%		10%	
	r	F	r	F	r	F	r	F	r	F	r	F	r	F	r	F	r	F	r	F
1/8	7.034	.408	6.833	.413	6.646	.419	6.303	.429	6.000	.439	5.730	.448	5.487	.457	5.266	.466	5.070	.474	4.889	.482
1/7	6.263	.442	6.197	.446	5.956	.451	5.638	.471	5.444	.470	5.225	.478	5.027	.487	4.847	.495	4.681	.502	4.530	.510
1/6	5.464	.484	5.348	.488	5.237	.492	5.033	.501	4.848	.509	4.676	.516	4 521	.524	4.379	.531	4.247	.538	4.125	.545
1/5	4.687	.537	4.555	.541	4.478	.545	4.333	.552	4.200	.559	4.080	.566	3.963	.572	3.858	.578	3.759	.584	3.667	.590
1/4	3.778	.609	3.727	.612	3.680	.615	3.586	.620	3.500	.626	3.420	.631	3.344	.036	3.273	.641	3.216	.646	3.143	.651
1/3	2.887	.707	2.860	.710	2.835	.712	2.786	.716	2.741	.720	2.695	.723	2.653	.727	2.613	.731	2.575	.734	2.540	.737
2/5	2.430	.773	2.410	.774	2.396	.776	2.364	.779	2.333	.781	2.304	.784	2.277	.789	2.280	.790	2.225	.702	2.200	.794
1/2	1.962	.850	1.952	.851	1.942	.852	1.926	.854	1.910	.856	1.892	.857	1.877	.859	1.860	.860	1.847	.862	1.833	.863
2/3	1.487	.938	1.482	.939	1.479	.939	1.472	.940	1.465	.940	1.459	.941	1.453	.942	1.446	.942	1.440	.943	1.435	.944
3/4	1.325	.966	1.323	.067	1.320	.967	1.316	.967	1.313	.968	1.309	.968	1.305	.968	1.301	.968	1.298	.969	1.296	.970
4/5	1.244	.979	1.242	.979	1.241	.979	1.236	.979	1.335	.979	1.23	.980	1.230	.980	1.227	.980	1.225	.981	1.222	.981

$$247 = \frac{42.688 \times 600 \times A}{33{,}000}$$

from which, area of high-pressure piston $= A = 318.24$ square inches.

In a similar manner we have for the low-pressure cylinder,

$$\text{Area of piston} = A_2 = \frac{33{,}000 \times 253}{10.944 \times 600}$$

$= 1271.5$ square inches.

Or, since the ratio of cylinders has been taken 4 to 1,

Area of low-pressure piston $= 318.24 \times 4 = 1272.96$ square inches.

The diameters giving the areas nearest to these values may be found in any convenient table of areas of circles, and the length of stroke and number of revolutions fixed upon according to conditions in such proportions as to give the piston speeds called for. Diameters are 20⅛ and 40¼ inches, neglecting influence of size of piston rods on crank or lower end.

It is believed that the above method, as outlined, has certain advantages over methods usually given, although strict accuracy with any method can not be expected. With saturated steam the point of cutoff in the low-pressure cylinder would, in practice, be varied somewhat in order to hold the receiver pressure at the desired point, but with the receiver jacketed the value fixed by the theoretical discussion would probably be nearly correct.

Independent determination of the card factor to give the mean effective pressure that may confidently be expected in the actual

Progress of Naval Vessels.

The Bureau of Construction and Repair, Navy Department, reports under date of October 10, 1906, the following percentage of completion of vessels building for the United States Navy:

			Sept. 1	Oct. 1
BATTLESHIPS.				
Nebraska	19 knots.	Moran Brothers Co.	96.38	96.71
Georgia	19 "	Bath Iron Works	99.6	100.
Connecticut	18 "	Navy Yard, New York, N. Y.	99.08	99.7
Vermont	18 "	Fore River Shipbuilding Co.	92.7	93.6
Kansas	18 "	New York Shipbuilding Co.	87.	91.
Minnesota	18 "	Newport News Co.	95.	96.
Mississippi	17 "	Wm. Cramp & Sons	62.18	65.52
Idaho	17 "	Wm. Cramp & Sons	60.29	62.41
New Hampshire	18 "	New York Shipbuilding Co.	51.8	53.3
ARMORED CRUISERS.				
California	22 knots.	Union Iron Works	95.	95.7
South Dakota	22 "	Union Iron Works	93.	93.2
North Carolina	22 "	Newport News Co.	57.18	61.09
Montana	22 "	Newport News Co.	51.03	54.28
SEMI-ARMORED CRUISERS.				
Milwaukee	22 knots.	Union Iron Works	98.5	98.9
SCOUT CRUISERS.				
Chester	24 knots.	Bath Iron Works	44.97	47.4
Birmingham	24 "	Fore River Shipbuilding Co.	44.9	47.4
Salem	24 "	Fore River Shipbuilding Co.	45.	47.5
SUBMARINE TORPEDO BOATS.				
Cuttlefish		Fore River Shipbuilding Co.	84.9	89.
Viper		Fore River Shipbuilding Co.	73.	73.
Tarantula		Fore River Shipbuilding Co.	85.9	90.
Octopus		Fore River Shipbuilding Co.	69.9	74.4

THE TURBINE-PROPELLED STEAMER KAISER.

BY DR. ALFRED GRADENWITZ.

The Hamburg-American Line has been the first among German steamship companies to adopt turbine propulsion for one of their express steamers, the *Kaiser,* built at the Vulkan Shipyards at Stettin, being intended for regular service between Hamburg and the German North Sea bathing-places. This steamer was completed in the short interval of fourteen months. She is 96 meters (315 feet) in total length, 11.65 meters (37.2 feet) in breadth, and with a draught of 3.03 meters (10.8 feet), has a displacement of 1,923 tons. She is able to accommodate 2,000 passengers. Four water-tube boilers constructed by the Vulkan firm have been provided, supplying steam at 15 atmospheres pressure (220 pounds per square inch). The stoking is operated on the Howden forced draught system, the air for combustion being preheated in a regenerator by the escaping furnace gases, and the feed water by the exhaust steam of the auxiliary engines.

STERN VIEW OF TURBINE-PROPELLED EXPRESS STEAMER KAISER.

The turbine plant, constructed by the Allgemeine Elektrizitäts Gesellschaft, comprises two units of an aggregate of 6,000 horsepower, each of which operates a shaft with one propeller. The turbines are pressure stage turbines on the Curtis system, the rotary part comprising five multiple-rim paddle wheels, with an equal number of pressure stages, to which a drum with a large number of paddle rims is connected. After at first working in the five paddle wheels, the steam acts on the rims of the low-pressure drum, leaving the last rim to enter the condenser through the exhaust compartment.

A backward turbine working in two pressure stages (each of which comprises several rims) has been arranged on the same shaft in the same casing.

After having been designed in July, 1904, the first of these turbines was, at the end of March, 1905, taken to the testing floor of the turbine works, where the two units with condensers and auxiliary engines were submitted to rather severe tests, at heavy overloads. Tests were made with superheated steam and with different vacua, using as load in the place of the propellers a specially constructed hydraulic brake.

A six hours' delivery test at full load by means of the water brake was finally carried out on each turbine at 600 revolutions per minute. A weight of 70 tons had been allowed for each unit; but the complete turbine, inclusive of the bearings, thrust bearings and oil pumps, in addition to all the pipes required for oil and draining, worked out at a weight of only 57 tons. After having been sent to Stettin as a whole, the turbines were lowered by means of cranes into the engine room of the steamer, and after having there been fitted, a short test was carried out with uncoupled propeller, showing that the engines worked quite smoothly on the ship-foundation.

The steamer first went to sea on August 16, 1905, running a number of trial trips in the Baltic Sea up to the 10th of September, which trips were intended to ascertain the most favorable propeller construction for the given output of 3,000 horsepower and with 600 revolutions per minute. In the extremely short interval of less than four weeks, trial trips were carried out with four different propellers, which was rendered possible

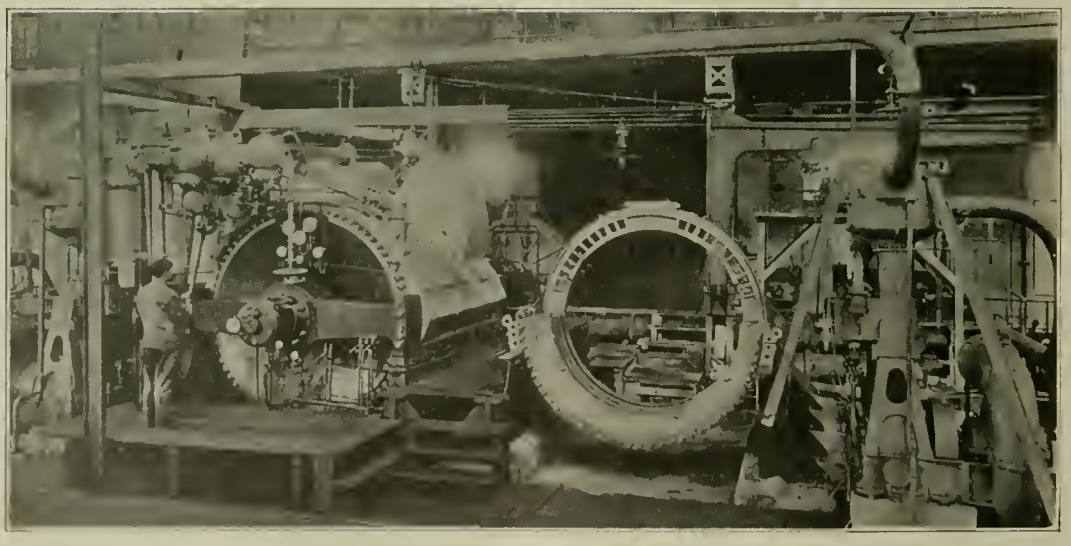
only by the fact that not the least hitch occurred in the turbine plant throughout these trips.

The final trial trip was carried out with the propellers finally chosen, in rather unfavorable weather, when the ship made, as an average of two hours, 20.46 knots, as against a guaranteed speed of 19.5 knots. The total consumption of coal had been guaranteed at 4.7 tons per hour with a speed of 19.5 knots, corresponding to figures which should have been obtained for triple expansion reciprocating engines. During the two hours' coal consumption test the total consumption of coal, including that for all the accessory machinery, with 20.05 knots, was found to be only 4.06 tons per hour, working out at 0.66 kilograms (1.46 pounds) per horsepower hour. Now this economy is 20 percent greater than that guaranteed. It should also be mentioned that the operation of the engines has been considerably simplified, only the auxiliary machinery requiring any attendance worth speaking of.

The simplicity and ease of control of the turbines is especially remarkable, and has been acknowledged by all experts having had an opportunity to inspect them; in fact any reversing of steam paths for different speeds has been avoided, only a single controlling valve being provided for regulation from zero to the full number of revolutions, the same valve operating the astern turbine after reversing a slide. The efficiency of the astern turbine is so satisfactory that while being very easily controlled, the steam consumption is only slightly higher than that of the forward turbine, thus maintaining the full boiler pressure even in the case of a continued backward course. The time required from "full speed ahead" to the backward course is about the same as in the case of equivalent reciprocating engine vessels.

THE HAMBURG-AMERICAN TURBINE STEAMER KAISER.

Turbo-dynamos of the A. E. G.-Curtis system are used for lighting the steamer, all the lamps on deck, in the saloons, dining-halls, cabins, etc., deriving their current from two units of 20 kilowatts each. The same machines yield the current for the operation of the smaller auxiliary machinery, such as laundry machines, refrigerating machinery, etc.



ASSEMBLED 3,000-HORSEPOWER TURBINE ON TESTING FLOOR. ANOTHER BEING ASSEMBLED.

The turbines, direct coupled to the dynamo, are single-stage turbines with three speed stages, thus possessing only a single wheel provided with three rims of vanes. The dynamo has been arranged between two bearings, outside of which the casing of the turbine has been fitted. The turbine wheel is made from best class steel, and has been fitted to the end of the dynamo shaft, thus insuring a high simplicity and stability, in addition

to a small weight. After entering through the main throttle valve into the steam-regulating compartments, the steam gets to the nozzles, in which the pressure is entirely converted into speed. The spring regulator fitted to the free shaft end acts through a rod on a throttling valve in the steam compartment. The turbines are connected to the central condensing plant. These small machines are operated with exhaust during the time the steamers are in the harbor, thus dispensing with the operation of the large central condensing plant. The nozzles especially provided for exhaust are closed by hand in case the turbines are to be operated for condensing in continual service. The bearings receive their oil from a valveless wheel pump under pressure, the bushes being cooled with water.

The dynamo has been designed as shunt dynamo, possessing two auxiliary poles, to avoid any sparking of the brushes in the case of variable loads. It is able to run from zero to full load without any displacement of the brushes, which are of carbon.

After having been taken over by the Hamburg-American Line on September 23, 1905, the *Kaiser* performed some trips to Helgoland and Sylt in the course of the ensuing weeks. In connection with these trips, several of which were performed in very bad weather, the steamer proved superior to the ships propelled by reciprocating engines. With a heavy north-west gale (wind intensity 10) the *Kaiser* was able to make headway against the wind at a speed of 17 knots, being the last ship that could enter the harbor against the storm. This satisfactory behavior should be ascribed both to the shape and construction of the hull, and to the use of the turbines for the propulsion of the vessel. Whenever, owing to the pitching of the ship, the screws issued from the water, which phenomenon is very frequent in the case of stormy weather, the behavior of the vessel was especially remarkable. In fact, whereas in the case of reciprocating engines a large increase in the number of revolutions is observed, resulting in heavy shocks to the hull (to offset which effect the steam should be throttled in such cases, thus requiring a permanent attendance) only a very slight increase in the number of turns was observed with the turbines of the *Kaiser*, necessitating no steam throttling. The smooth running of the vessel was not interfered with in any way, nor was the issuing of the screws at all noted by the passengers.

LOW-PRESSURE END OF ROTOR OF PROPELLING TURBINE AND DYNAMO ROTOR.

THE BATTLESHIP VIRGINIA THROWING UP A HUGE MASS OF SPRAY AND FOAM.
(Copyright, 1906, N. L. Stebbins.)

DEVELOPMENT OF THE MARINE STEAM TURBINE.*

BY HON. C. A. PARSONS AND R. J. WALKER.

During the last few years the steam turbine has formed the subject of many papers read before various leading institutions, and its different applications have often been referred to. It is hardly within the scope of this paper to deal in detail with the earlier experiments and trials which have led up to the present satisfactory position of the turbine. It may be of interest, however, to briefly describe the various steps that have been made from time to time in the development.

In 1884 the first Parsons compound steam turbine engine was built, and was applied to the driving of a dynamo. This engine was designed for 10 horsepower, with a modified high-speed dynamo, and for a working speed of 18,000 revolutions per minute. It ran for some years, doing useful work, and is now in South Kensington Museum. Subsequently, efforts were made towards the construction of engines of larger size, which resulted, in the year 1888, in several turbo-alternators of 120 horsepower being supplied for the generation of current in electric light stations, and at that period the total horsepower of turbines at work reached in the aggregate about 4,000, all of which were of the parallel flow type and non-condensing.

In 1892 the steam turbine was first adapted to work in conjunction with a condenser. This engine was capable of developing 200 horsepower at a speed of revolution of 4,800 per minute, and drove an alternator of 150-kilowatt output. It was tested by Professor Ewing, F. R. S., and the result of the test showed a consumption of steam of 27 pounds per kilowatt hour, which is equivalent to about 16 pounds per I. H. P., with steam moderately superheated, and a vacuum of 28 inches. Since then, various improvements have been made, until at the present time the steam turbine is generally recognized to be an efficient and practical engine, which, in the larger sizes, has attained a high degree of economy in steam.

The following table shows the advance made in sizes and increased economy in steam consumption as applied for electrical purposes:

Date.	Capacity kilowatts.	Steam per kilowatt hour, lbs.	Vacuum inches.	Superheat degrees F.	Steam pressure per square inch, lbs.
1887	75	50.	....	...	120
1892	100	27.	27	50	...
1898	1250	18.81	28	180	130
1901	1000	17.30	27	198	150
1902	3000	14.74	27	235	138
1904	4000	15.40	28.7	150	200

Superheating of the steam has been adopted in the case of land turbines, and it has been found by experiments that for every 10 degrees F. of superheat, the steam consumption is reduced by about one percent.

Fig. 1, which is based upon a large number of tests, shows the steam consumption of different sized plants per kilowatt-hour without superheating, from which it will be noted that the efficiency increases steadily as the size grows larger.

Turbine engines are also used for generating electrical current for the transmission of power, the working of electric tramways, railways, electric pumping, coaling and similar purposes. They are also used for coupling direct to fans, and driving them for producing forced and induced draft for general ventilating purposes; also for driving centrifugal and screw pumps, and also for the more important work of driving blowers for supplying air under pressure, for blast furnaces and other purposes.

Land turbines have been very largely adopted in the past few years for the generating of electricity, judging from the fact that these machines are running in England in the power stations of some forty corporations and of twenty-five public electric supply companies. One of the largest power stations in England, now approaching completion, contains two units of 3,000 horsepower and six units of 6,000 horsepower each. The total horsepower of turbines of the Parsons type delivered and on order, including turbines at work and under construction by licenses on the continent and in the United States at the present time, for land purposes is nearly 2,000,000. The installations now on order include units of upwards of 10,000 horsepower.

The application of the steam turbine to the propulsion of ships has attracted a great deal of attention in the shipbuilding world within the last few years.

It was not until the year 1894 that the idea of propelling a vessel by means of a steam turbine was put into practical form. The *Turbinia*, as is now generally known, was the first vessel to be fitted with turbine engines, and between the years 1894 and 1898 many experiments were made with the *Turbinia*, necessitating radical changes in the design and arrangement of the machinery. The first engine which was tried was of the radial flow type, giving about 1,500 horsepower to a single screw. The results, however, were far from satisfactory, a speed of only 18 knots being obtained. Several different propellers were tested with this engine, and the results compared with the power registered by a dynamometer showed in every case a very low propeller efficiency. The original turbine engine was removed, and the engines finally adopted consisted of three turbines in series; high-pressure, intermediate-pressure and low-pressure, each driving a separate shaft, with three propellers on each shaft.

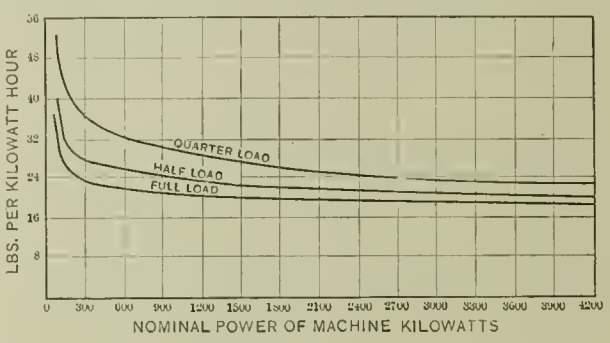


FIG. 1.

A reversing turbine was coupled with the low-pressure turbine to the central shaft. Very exhaustive trials were carried out by Professor Ewing in 1897. A full account of these trials will be found in the *Transactions of the Institution of Naval Architects*, Vol. XLV (1903).

Following the success of the *Turbinia*, the torpedo boat destroyers *Viper* and *Cobra* were built and fitted with turbine machinery for the Royal Navy, and achieved remarkable speeds, the *Viper* taking the position of being the fastest vessel in the world, having attained the phenomenal speed of 36.88 knots. Unfortunately, however, the *Viper* ran on the rocks of the Channel Islands in a fog, and ultimately became a total wreck. The *Cobra* foundered in a storm. Thus, after two or three years of hard work, the *Turbinia* was the only vessel afloat fitted with turbine engines.

About this period very great difficulty was experienced in endeavoring to induce railway companies and owners of mercantile vessels to build a turbine boat. Each company appeared anxious that someone else should make the first experiment.

The marine turbine was first adopted for commercial purposes in the Clyde steamer *King Edward*, to the order of Captain Williamson, in the summer of 1901. So successful was this vessel during the first season's running on the Clyde (the year of the great Exhibition at Glasgow), that an order was placed for a second vessel, *Queen Alexandra*, and the performance of these two vessels running on the Firth of Clyde demonstrated the commercial advantages accruing from the adoption of the turbine system. Other vessels quickly followed the *King Edward* and *Queen Alexandra*, until there are at the present time thirty-one turbine vessels in service for commercial purposes, representing

*Paper read before the Engineering Congress at the Olympia Engineering Exhibition, London.

a total of about 105,000 gross tonnage and 235,000 indicated horsepower.

The following table will perhaps best represent the various steps in the adoption of the turbine engine for commercial purposes:

Name of vessel and owners.	Dimensions.	Gross tonnage.	Approx. I. H. P.	Year built.
King Edward—				
Turbine Steamers, Ltd.	250x30x17¾	562	3,500	1901
The Queen—				
S. E. & Chat. Ry. Co.	310x40x25	1,676	7,300	1903
Virginian—				
Allan Line	520x60x41	10,754	12,000	1904
Carmania—				
Cunard Line	678x72x52	19,524	21,000	1905
Lusitonia—				
Cunard Line	785x88x60½	32,500	70,000	1906

As regards war vessels, the destroyers *Velox* and *Eden* were the next vessels following the *Viper* to be built for the British Admiralty. These two vessels were fitted with additional engines for obtaining economical results when cruising at low speeds. The next vessel to be fitted with turbines for the British Admiralty was the third-class cruiser *Amethyst*. This vessel was also fitted with cruising turbines, and the results of the trials, as compared with sister vessels ordered at the same time as the *Amethyst*, and of the same dimensions and lines, but fitted with reciprocating engines, demonstrated the economy of the Parsons marine turbine as fitted in this class of vessel, and more especially at the higher powers.

	Princesse Elisabeth.	*Princesse Clementine.*	*Marie Henriette.*	*Leopald II.*
Length between perpendic.	104m.85	103m.70	103m.70	103m.70
Breadth	12m.192	11m.58	11m.58	11m.58
Mean draft	2m.92	2m.85	2m.82	2m.82
Displacem't in metric tons..	2,005	1,853	1,847	1,829
Registered tons	1,747	1,474	1,450	1,375
Type of engines	Turbines	Compound	Compound	Compound
Speed on trial, knots	24	22.187	22.2	22
Date of construction	1905	1896	1893	1893

In the year 1905 the mean consumption of coal per single trip and the mean time per trip from Ostend to Dover and vice versa, of the four preceding vessels, were as follows:

	P. E.	P. C.	M. H.	L. II.
Total number of trips	82	278	278	232
Mean duration of trips, minutes	187	217	212	227
Mean consumption per trip, tons	23.01	24.05	23.82	24.30

For the six first months of the year 1906 the corresponding results were the following:

	P. E.	P. C.	M. H.	L. II.
Total number of trips	134	132	106	44
Mean duration of trips, minutes	185	210	206	202
Mean consumption per trip, tons	22.71	23.22	24.27	24.87

	Turbine boat.	Mean result paddle steamers.
Total number of trips	216	1,070
Mean duration of trip, minutes	186	218
Mean consumption per trip, tons	24.06	24

From the above table, it will be seen that the turbine boat does the passage in about 15 percent less time than the paddle steamers, on the same coal consumption. To reduce the turbine

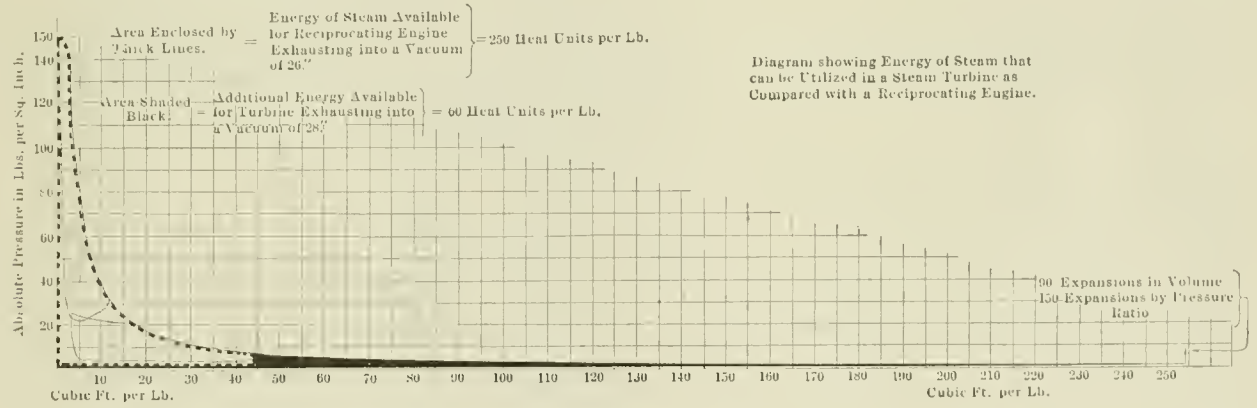

Area Enclosed by Black Lines. = Energy of Steam Available for Reciprocating Engine Exhausting into a Vacuum of 26" = 250 Heat Units per Lb.
Area Shaded Black = Additional Energy Available for Turbine Exhausting into a Vacuum of 28" = 60 Heat Units per Lb.
Diagram showing Energy of Steam that can be Utilized in a Steam Turbine as Compared with a Reciprocating Engine.
Absolute Pressure in Lbs. per Sq. Inch.
90 Expansions in Volume
150 Expansions by Pressure Ratio
Cubic Ft. per Lb.
Cubic Ft. per Lb.

FIG. 5.

The battleship *Dreadnought* is one of the latest war vessels to be fitted with turbine engines. This vessel's turbines, which were manufactured by the Parsons Marine Steam Turbine Company, Limited, at the Turbinia Works, have now been installed, and the vessel is being prepared for trials. Particulars are given in the Memorandum of the Navy Program of new construction, of the various war vessels which are at the present time being built, some of which are now nearing completion.

Comparisons of the earning powers of turbine vessels have been made from time to time with similar vessels on the same respective routes, which have been found to be favorable to the turbine,and in some cases the saving in coal is very considerable. A full account of these comparisons will be found in the *Transactions of the Institution of Civil Engineers*—"The Steam Turbine," by the Hon. C. A. Parsons and G. Steney,—and in the *Transactions of the Liverpool Engineering Society*—"Progress made in the Application of the Parsons Turbine to Marine Propulsion," by R. J. Walker.

By the courtesy of Monsieur Pierrard of the Belgian Government, particulars are just to hand of the first season's running of the turbine steamer *Princesse Elisabeth* on the Ostend and Dover service, and are given in the following table, along with the particulars of similar vessels on the same service, but fitted with paddle engines:

boat to the displacement and speed of the paddle boats, and assuming that the indicated horsepower varies as the cube of the speed, the mean consumption of the *Princesse Elisabeth* would be about 17 tons, as against 24 tons in the paddle boats, thereby showing a saving of over 25 percent.

The following mercantile vessels have been completed and placed on service this year:

The pleasure and mail steamer *Rewa* for the British India Steam Navigation Company, Ltd., of 455 by 56 feet and 16½ knots speed; the Clyde passenger steamer *Duchess of Argyll*, for the Caledonian Steam Packet Company, of 250 by 30 feet and 20 knots speed; the Thames passenger steamer *Kingfisher* for the General Steam Navigation Company, of 275 by 32 feet and 20 knots speed. The three cross-channel steamers for the Great Western Railway Company's new route, Fishguard to Rosslare, viz., *St. David*, *St. Patrick* and *St. George*, of 350 by 41 by 13½ feet and 22½ knots speed; the cross-channel steamer *Viper* for Messrs. G. & J. Burns, of 315 by 39½ by 12 feet and 21¾ knots speed; and another Clyde passenger steamer, the *Atalanta*, for the Glasgow and South Western Railway Company, of 210 by 27 by 10½ feet, and 17½ knots speed. In addition to the above, the two Great Central Railway steamers are nearing completion, and will, it is anticipated, be put on service this year, and the Khedival yacht *Mahrousso*, which has been

re-engined by Messrs. A. & J. Inglis, has run her trials, and a speed of 17½ knots was attained.

In addition to the large number of war vessels that are now being built and fitted with turbine machinery by some eight of the Parsons Marine Company's licenses, and also in addition to the two express Cunarders by Messrs. J. Brown & Company and Messrs. Swan, Hunter & Wigham Richardson, Ltd., and the Wallsend Slipway & Engineering Company, the following mercantile orders are in hand: Two large ocean-going liners by the Fairfield Shipbuilding & Engineering Company; two cross-channel steamers for the South Eastern & Chatham Railway, similar to the *Onward* and *Invicta;* and a further steamer for the Union Steamship Company of New Zealand, by Messrs. Denny; two large sets of turbine engines for shipment to Japan by the Turbinia Company at Wallsend, and the Royal yacht, building by Messrs. Inglis, the turbine engines for which are being manufactured at the Turbinia Works, Wallsend, representing a total horsepower of work in hand of about 500,000.

Although the turbine itself has been described in various publications which are now being issued, it may be of interest to some of the members to briefly describe the principle of the Parsons turbine, and to mention a few points incidental to the application of the turbine system to different classes of vessels.

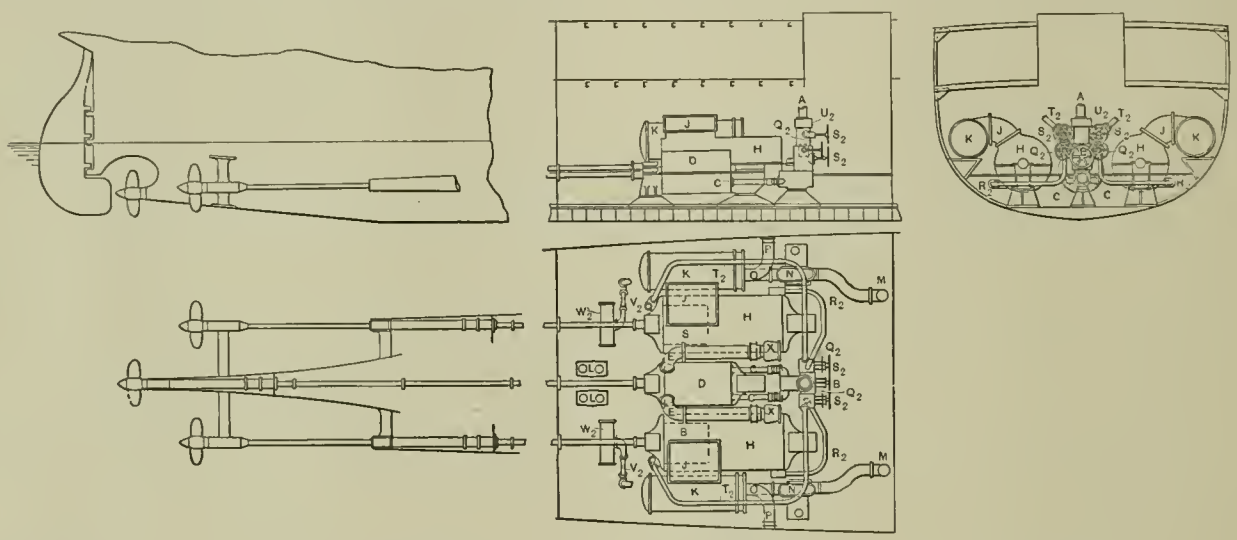


FIG. 2.—THREE-SHAFT ARRANGEMENT OF TURBINE MACHINERY.

A Steam from Boilers.
B Main Regulator Valve.
C Steam to High Pressure Turbine.
D High Pressure Turbine.
E Exhaust from H.P. Turbine to Automatic Closing Valve.
E_3 Exhaust frum H. P. Turbioe to I. P. Turbioe.
E_4 Exhaust from H. P. Turbioe to L. P. Turbine.
F Intermediate Pressure Turbine.
G Exhaust from I. P. Turbine to L. P. Turbioe.
H Low Pressure Turbine.
J Exhaust to Coodenser.
K Condenser.
L Air Pump.
M Main Inlet to Circulating Pump.
M_4 Steam to H. P. Astern Turbine.
N Circulating Pump.
N_4 High Pressure Astern Turbine.
O Circulatiog Discharge to Condenser.
O_4 Exhaust from H. P. Astern Turbine to L. P. Astero Turbine.
P Condenser Discharge Overboard.
P_4 Low Pressure Astern Turbine.
Q Astern Regulator Valve.
Q_2 Maneuvring Valve, L. P. Ahead.
Q_4 Regulator Valve to H. P. Cruising Turbine.
R Steam to Astern Turbine
R_2 Steam to L. P. Ahead Turbine.
R_4 Steam to H. P. Cruising Turbine.
S Astern Turbine.
S_2 Maneuvring Valve, L. P. Astern.
S_4 High Pressure Cruising Turbine.
T Cruising Regulator Valve.
T_2 Steam to Low Pressure Astern.
T_4 Exhaust from H. P. Cruising Turbine to Self-Closing Valve.
U Steam to Cruising Turbine.
U_2 Governor Valve.
V Cruising Turbine.
V_2 Vacuum Augmentor.
V_4 I. P. Cruising Turbine.
W Exhaust from Cruising Turbine to Automatic Closing Valve.
W_2 Vacuum Augmentor Condenser.
X Automatic Closing Valve.
Y Direct Steam Regulator Valve to I.P. Cruising Turbine.
Z Direct Steam to I.P. Cruising Turbine
a Exhaust from H. P. Cruising Turbine to Self-Closing Valve, when Engine Rooms are Independent.
b Self-Closing Valve.

References are to Figs. 2, 3 and 4.

In regard to the arrangement of turbines, this depends partly on the condition of service, and the various classes of vessels require, more or less, to be taken upon their own merits. The arrangement which has been almost universally adopted in the mercantile marine is that of dividing the power equally over three shafts, viz., a high-pressure on the center shaft, exhausting into two low-pressure turbines, one on each side of the vessel. Fig. 2 shows a three-shaft arrangement of machinery. In such a case the high-pressure turbine is made suitable for an expansion ratio of about five, and the low-pressure for twenty-five. The turbines are of the parallel flow type, the general course of the steam through them being parallel to the axis.

Each turbine consists of a number of rings of blades or vanes mounted on a drum or rotor. This rotor is inclosed within a cylindrical case, upon which rings of blades are also fitted. The rings of blades are alternately fixed and moving, that is to say, the blades in the cylinder are stationary or guide blades, while the blades fitted on the drum are moving blades. The diameter of the drum is less than that of the cylindrical case, and thus an annulus is left between the two, which is occupied by the blades. Steam issuing from the boilers flows through the first row of fixed or guide blades on the cylinder; it then, in jets of moderate velocity, impinges on the moving blades, and imparts to them a rotary motion, this process being repeated on each successive ring of fixed and moving blades throughout the turbine.

As the steam passes from ring to ring it falls in pressure and increases in volume, and to meet this expansion the blades are increased in height by steps. The areas of the steam passage through the blades thus gradually increase from one end of the turbine to the other, to correspond to the expansion in volume of the steam for the range of pressures from beginning to the end of the turbine.

The turbine shaft is coupled to the propeller shafting, and the thrust of the propeller is steam borne by the following arrangement:

Forward of the steam inlet a dummy piston is fitted, of reduced diameter to that of the main drum. A large number of small grooves are turned in this dummy piston, into which fit corresponding fixed brass rings, which are bedded into the dummy casing, forming steam baffles. The steam presses aft on the blades and on the annular part of the drum forming the step between the drum and the dummy piston, and the sum of these pressures balances the thrust of the propeller. To meet any unbalanced thrust, such as is set up when steam is turned on or off suddenly, and to maintain the true longitudinal alinement of the rotors, a small thrust block is provided at the forward end of the bearing. Where the turbine shaft passes through the casing, steam-packed glands are fitted. These glands consist of a number of rings or strips arranged in series, and designed to obtain a gradual rise or fall in pressure from the inner or steam end to the outer or atmospheric end of the gland. Valves are fitted to these glands to regulate the pressures, and to insure

against leakage of air inwards. All the main bearings are under oil pressure, and the oil is discharged from the pump at a pressure of from 8 to 10 pounds, or at such a pressure as to insure the efficient lubrication of all bearings.

In the exhaust casing of each of the low-pressure turbines a reversing turbine is fitted.

By means of suitable valves when maneuvering, the low-pressure and astern turbines on each side of the vessel are capable of being worked ahead or astern as required, independently of the high-pressure turbine, the latter, under such conditions, running idly in a vacuum. By this arrangement, the vessel has all the maneuvering qualities of a twin-screw vessel.

In torpedo boats, a similar arrangement is adopted as in the *Turbinia*, viz., three in series, Fig. 3, with one astern on the center shaft only. This arrangement permits of a reduced weight being obtained as compared with the high-pressure and two low-pressures in parallel for equal efficiency.

In very large powers, it is desirable to divide the power over four shafts (Fig. 4), thereby increasing the revolutions and reducing the size of the units. The four-shaft arrangement lends

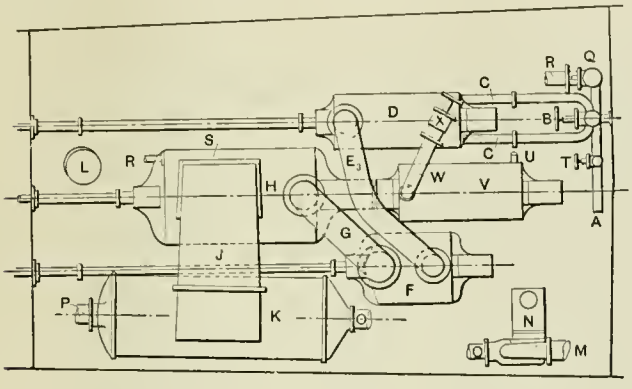


FIG 3.—ANOTHER THREE-SHAFT ARRANGEMENT.

itself well to large war vessels, as two complete sets of engines are obtained, one high-pressure and one low-pressure with condensing plant in each engine room. A two-shaft arrangement was adopted in the yacht *Narcissus*, which gave very good results; but for powers over 2,500 to 3,000 a two-shaft arrangement entails additional weight.

One of the chief difficulties which had to be contended with in applying the steam turbine to the propulsion of ships arose in connection with the propellers. It is desirable, for obvious reasons, that a turbine for a given efficiency should be designed to run at as high a rate of revolution as possible, consistent with propeller efficiency. The speed of turbines for land purposes is considerably higher than is permissible for marine purposes, where the speed of rotation is limited by considerations of propeller efficiency. The question of design of propeller, and turbine dimensions, require to be considered independently, and also to arrive at the best compromise to meet the conditions required, *i. e.*—as to weight, space, efficiency, and conditions of service. With a view of increasing the revolutions, the diameters of the propellers and pitch ratios are less than is usual in the case of ordinary reciprocating engines, the smaller diameter of propeller necessitating higher ratios of blade surface to disk area than hitherto attempted with ordinary propellers.

In some of the earlier vessels multiple propellers were tried, but subsequent experiments showed that single propellers on each shaft were preferable. The loss of efficiency which has been observed in some of the vessels fitted with multiple propellers appears to have been due partly to interference from the forward screws, and partly to cavitation. Although more light might yet be thrown on the question of high speed propeller efficiency, a considerable amount of experience has now been obtained with turbine driven propellers, which enables a close estimate to be made as to the efficiency which might be expected in a given design where reliable data as to horsepower necessary for the proposal in question can be obtained.

On account of the greater range of expansion dealt with in the turbine as compared with the reciprocating engine, a good vacuum is much more essential in the former than in the latter, and because of the importance of a high vacuum with the steam turbine, careful consideration requires to be given to the condensing plant. With a view of maintaining a high vacuum, a new apparatus has been introduced, to assist the ordinary air pump and condenser, known as the Vacuum Augmentor. The augmentor consists of a small steam jet placed in a contracted portion of a pipe, led from the bottom of the condenser. The jet draws air from the condenser, and delivers it to the air pump through a small auxiliary cooler. By this means the air is reduced to a negligible quantity. The vacuum augmentor has now been fitted in several vessels with very good results. As an illustration of the importance of high vacuum, Fig. 5 shows the energy of steam that can be utilized in a steam turbine, as compared with a reciprocating engine.

Another point which has often been referred to in connection with turbine machinery is the question of boiler pressure. The effect of differences of boiler pressure between 150 and 200 pounds is relatively smaller with turbines than with reciprocating engines, and it is very questionable, in the majority of cases, whether the saving in coal by the adoption of high boiler pressures would justify the increase. More especially is this the case in moderate speed vessels, where, to obtain reasonable propeller efficiency, a certain diameter of propeller is necessary, and the revolutions to correspond are moderately low. It is necessary to obtain a certain surface speed of turbine, as well as a certain number of rows of turbine blades, to obtain reasonable economy. The diameter of the turbine, therefore, becomes

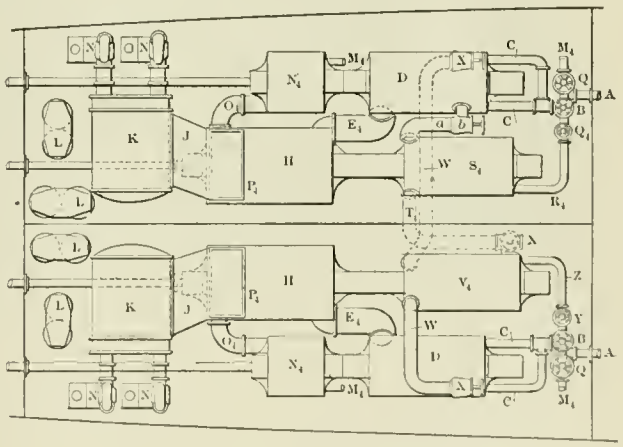


FIG. 4.—FOUR-SHAFT ARRANGEMENT.

greater in proportion to the power, and the blade heights in the annulus between the drum and the casing are relatively shorter; this gives a relatively greater clearance loss. The clearance area is practically constant for a given diameter, so that with higher pressures and denser steam the loss through clearance space will be greater.

Another point which has been greatly discussed in connection with turbine machinery is the question of the method of measuring the horsepower developed by the turbine engines. As is now more or less generally known, it is not possible to indicate the power of the turbine as in the ordinary method of the indicator diagram of reciprocating engines. In the absence of any such method, it is found most convenient to take the estimated I. H. P. as the equivalent indicated horsepower which would be required with reciprocating engines for the particular class of vessel proposed. Messrs. W. Denny & Bros. have recently introduced a new dynamometer or torsion meter for obtaining the power transmitted by the shaft, the readings being obtained by

the torsional deflection of a given calibrated length of the main shafting. This instrument has been used on several vessels, and appears to give very reliable results; and where facilities are at hand for obtaining the effective horsepower by means of tank experiments the shaft horsepower, together with the effective

Vessel.	Length.	Beam.	Depth.	Tons.	Speed.
Steam yacht:					
Turbinia (a)	100	9	7	45*	34.5
Emerald (b)	198	28.7	18.5		15.
Lorena	253	33.3	20.3		18.01
Tarantula	152.5	15.3	8.8		25.36
Albion	240	34	20		15.
Narcissus	210	27.5			14.5
Mahroussa	400	42			17.5
Destroyer:					
Cobra	223.5	20.5	13.5		34.6
Viper (c)	210	21	12.5		36.88
Velox	210	21	12.5		27.12
Eden	220	23.5	13.8		26.23
River steamer:					
King Edward (d)	250	30	17.8	562	20:48
Queen Alexandra (e)	270	32	18.8		21.63
Duchess of Argyll	230	30			20.
Kingfisher	275	32			20.
Channel steamer:					
The Queen (f)	310	40	25	1,676	21.73
Brighton (g)	280	34	22		21.37
Princess Maud (h)	300	40	24.5		20.66
Londonderry	330	42	25.3		22.29
Manxman (i)	330	43	18		23.
Viking (j)	350	42	16		23.53
Princesse Elisabeth (k)	344	40	23.2	1,747	24.03
Onward	310	40	25		22.53
Invicta	310	40	25		22.5
Dieppe (l)	284	34.7	22		21.5
St. David	350	41			22.5
St. Patrick	350	41			22.5
St. George	350	41			22.5
Viper (m)	315	39.5			21.75
Atalanta	210	27			17.5
Cruiser:					
Amethyst (n)	360	40		3,000*	23.63
Torpedo boat (French):					
293 (o)	130	14			26.2
Transatlantic Liner:					
Virginian (p)	520	60	41	10,630	19.11
Victorian (p)	520	60	41	10,630	18.75
Carmania (q)	678	72	52	19,524	20.
Ocean steamer:					
Loongana	300	43	16.5		20.15
Moheno (r)	400	50	38.5		16.5
Lhasa	275	44	25.5		18.09
Linga	275	44	25.5		18.05
Lama	275	44	25.5		18.
Lunka	275	44	25.5		18.
Rewa	455	56			16.5
Bingera	300	40	19		16.
Lake steamer:					
Turbinia (s)	250	33	20.8	1,100*	18.46

* Displacement.

See Marine Engineering (*a*) 6, June, 1897; 11, July, 1897; 14, Dec., 1897; 28, Feb., 1898; 26, March, 1898; 1, Jan'y, 1899. (*b*) 196, April, 1903; 317, June, 1903. (*c*) 213, Nov., 1899. (*d*) 395, Sept., 1901; 8, Jan'y, 1902. (*e*) 422, August, 1902. (*f*) 528, Oct., 1903. (*g*) 10, Jan'y, 1904. (*h*) 323, July, 1904. (*i*) 487, Dec., 1905. (*j*) 443, Nov., 1905. (*k*) 488, Dec., 1905. (*l*) 247, June, 1905. (*n*) 37, Jan'y, 1905. (*o*) 43, Jan'y, 1905. (*p*) 359, Sept., 1905. (*q*) 1, Jan'y, 1906. (*r*) 489, Dec., 1905. (*s*) 427, Sept., 1904; 5, Jan'y, 1905. (*m*) International Marine Engineering, 321, August, 1906.

horsepower, form a very good basis for estimating propeller efficiency.

Other advantages incidental to the turbine might be cited, such as reduced weight of machinery, steadiness and smoothness of running, reduction in oil and stores, and absence of racing in a seaway, and other advantages which have brought the turbine to a commercial success.

The development of the marine turbine has taken place almost entirely in Great Britain. A few war vessels have been built in France and Germany. The reason that the Parsons marine turbine has made so little progress on the continent in the past is probably due to the fact that in France and Germany rival turbine systems of local origin have been energetically exploited, inducing those responsible for the ordering of new vessels to defer the adoption of a new system until the claimants had results to show.

The Parsons turbine was introduced to the continent by the small French torpedo boat No. 293. This boat, ordered by the French navy as an experiment in the year 1903, has been in continual service for over two years without any breakdown or repair, and continues to give in practice the results obtained on trial. Naturally, so small a boat hardly demonstrates the results which might be expected from larger installations. The above mentioned experimental torpedo boat is 130 by 14 feet, and of 95 tons displacement. She attained a speed of 26.2 knots. The arrangement of machinery is similar to that in the *Turbinia*, three turbines in series.

In France, a mail and passenger boat is being built for the Marseilles and Algiers service of the Compagnie Generale Transatlantique. She is 378 by 43 feet, and is designed for a service speed of 20 knots. In the United States five passenger vessels are being built, and a scout cruiser of 24 knots speed for the government, to be fitted with Parsons turbines.

Reference to the table will show the vessels which have been engined in Great Britain with Parsons turbines up to the present date, representing a total horsepower actually completed of about 280,000. The total horsepower of marine turbine engines completed and on order with the Parsons Marine Company and their licensees is over 870,000.

Comparison Between Turbines and Reciprocating Engines.

The illustration shows in one view one of the steam turbines to be fitted in the new scout cruiser *Salem*, building in the yards of the Fore River Shipbuilding Company, Quincy, Mass., and one of the triple expansion reciprocating engines fitted in the battleship *Vermont*, building in the same yard. In each case the requirement is for about 8,000 horsepower, so that the comparison is direct.

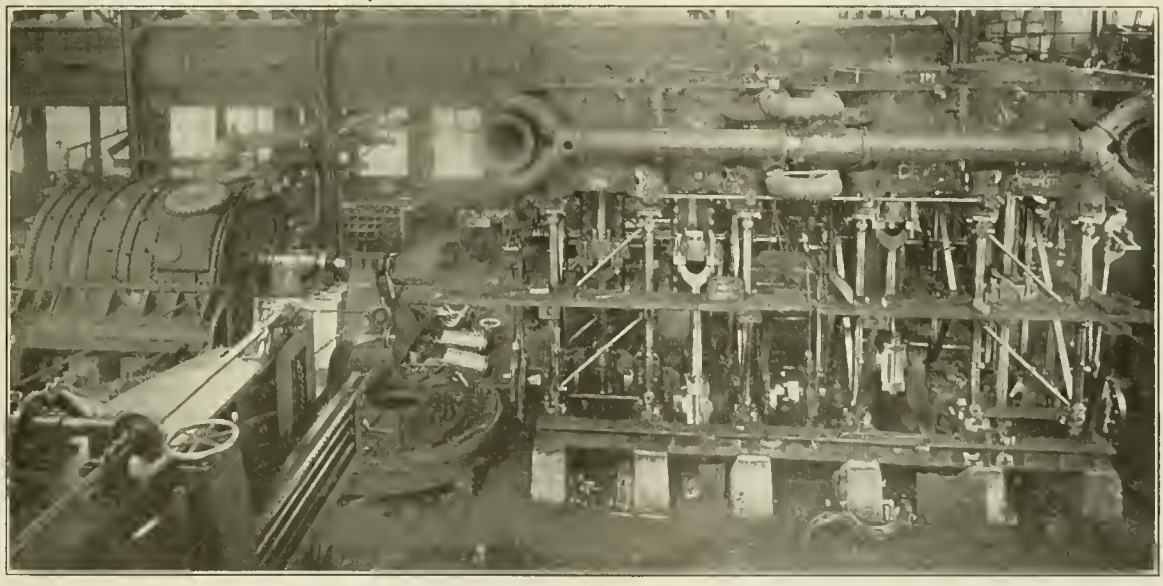
The turbine illustrated is identical in size and pattern with that illustrated in our October number in connection with the description of the new Southern Pacific steamer *Creole*, although it is of double the power of that turbine. This astonishing increase in power with the same turbine casing and rotor is obtained by the joint use of an increase in the number of revolutions and in the pressure of the steam, the former resulting from the latter. The number of nozzles admitting steam is also increased in the higher powered turbine.

The present turbine, which is of the 120-inch size, 7-stage, operates at 350 revolutions per minute and weighs 228,680 pounds, or a trifle more than 102 tons. This figures out at 28.6 pounds per horsepower. The reciprocating engine, which has four cylinders with diameters 32½, 53, 61 and 61 inches, and a common stroke of 48 inches, operates at 120 revolutions per minute, and weighs 343,350 pounds, or a little more than 153 tons, this being almost exactly 50 percent more than for the turbine. This weight figures out at about 43 pounds per indicated horsepower.

A comparison of the dimensions and space occupied by these two types of prime mover will be interesting.

	Turbine.	Engine.
Length over all	16 ft. 2¾ ins.	33 ft. 6½ ins.
Width over all	13 ft. 6 ins.	11 ft. 3 ins.
Height over all	12 ft. 6 ins.	21 ft. 9 ins.
Floor space	219 sq .feet.	377 sq. feet.
End area	169 sq. feet.	245 sq. feet.
Side area, or target	203 sq. feet	730 sq. feet.
Over all volume	2,735 cu. ft.	8,200 cu. feet.

In the above tables the areas and volumes are figured out from the gross dimensions in each case, and are, therefore, strictly comparable. The turbine shaft over all measures 23 feet 7 inches, while the crank shaft of the engine is 31 feet 1 inch. The length from center to center of main bearings of the turbine is 18 feet 6 inches, corresponding with 25 feet 8½ inches from center to center of the end bearings of the engine. The length over the stuffing boxes of the turbine is 14 feet 5½ inches. The length over all of the cylinders of the engine is 32 feet 9 inches. The width over all of the bedplate of the engine is 10 feet. The diameter of the flanges of the stuffing box casing of the turbine is 11 feet 2¾ inches. In the table the figures for the turbine are based on the over all dimensions of the casing.



ENGINE AND TURBINE, 8,000 HORSEPOWER EACH, IN SHOPS OF FORE RIVER SHIPBUILDING CO. [illegible].

The *Salem* is a scout cruiser measuring 420 feet between perpendiculars, with a beam of 47 feet 1 inch, a draft of 16 feet 9 inches and a displacement of 3,750 tons. A speed of 24 knots is expected on a total of 16,000 horsepower. The normal coal supply is 475 tons, which may be increased to a total of 1,250 tons with bunkers all filled. In the latter condition, and with a full supply of stores and ammunition on board, the displacement is 4,687 tons. The over all length is 423 feet 1 inch. The battery consists of twelve 3-inch rapid fire guns and two 21-inch submerged torpedo tubes. The contract price for hull and machinery was $1,556,000, the date of contract being May 17, 1905, and estimated date of completion March 17, 1908.

The *Vermont* is a first class battleship, measuring 450 feet between perpendiculars, with a beam of 76 feet 10 inches, a draft of 24 feet 6 inches and a displacement of 16,000 tons. A speed of 18 knots is expected with 16,500 horsepower. The normal coal supply of 900 tons can be increased to a maximum of 2,200, under which condition, with full stores and ammunition on board, the full load displacement is 17,650 tons. The over all length is 456 feet 4 inches.

The *Vermont* carries a battery of four 12-inch and eight 8-inch breech loading rifles mounted in pairs in turrets; twelve 7-inch rapid fire guns; twenty 3-inch and thirty smaller guns; and four 21-inch submerged torpedo tubes. The armor belt has a thickness of 9 inches; turrets and barbettes range from 12 inches down to 4 inches; the protective deck varies from 1½ to 3 inches. The contract price for hull and machinery was $4,179,000, the contract having been entered into on June 20, 1903, and calling for completion of vessel December 20, 1906. The keel was laid May 21, 1904, and the vessel launched August 31, 1905.

Society of Naval Architects and Marine Engineers.

Announcement is made of the program for the fourteenth general meeting of the Society of Naval Architects and Marine Engineers, which took place on Thursday and Friday, November 22 and 23, 1906, in the auditorium of the American Society of Mechanical Engineers at 12 West 31st street, New York City. A list of the papers read follows:

THURSDAY, NOVEMBER 22, 1906.

1. *A Fireproof Ferryboat*, F. L. DuBosque.
2. *Construction of a Fireproof Excursion Steamer*, William Gatewood.
3. *Speed and Power Performance of Albany Day Line Steamer NEW YORK*, Professor J. E. Denton.
4. *Personal Impressions of Model Towing Stations Abroad*, Professor C. H. Peabody.
5. *The Experimental Tank of the University of Michigan*, Professor H. C. Sadler.
6. *Model Basin Gleanings*, Naval Constructor D. W. Taylor, U. S. N.
7. *Comparison of the Durand and Curtis & Hewins Papers on Propeller Experiments of 1905*, Colonel E. A. Stevens.
8. *A Modern Fleet*, Captain E. B. Barry, U. S. N.
9. *Recent Developments in Armor and Armament*, John F. Meigs.
10. *The Development of War Ship Design*, Naval Constructor R. H. Robinson, U. S. N.
11. *Development of Submarines*, Lawrence Y. Spear.
12. *The Effect of the Universal Rule on Yacht Design*, Martin C. Erismann.
13. *The Gasoline Engine*, Arthur T. Chester.
14. *Two Timber Dry Docks and Their Pumping Plants*, F. P. Palen and G. L. Smith.
15. *A New Sea Anchor for Coaling at Sea*, Spencer Miller.

Following the meeting, a banquet was held at Delmonico's at 7 P. M. on Friday, the 23d of November. We expect to give in our January issue a full account of the meeting, with abstracts of the papers and the principal parts of the discussions.

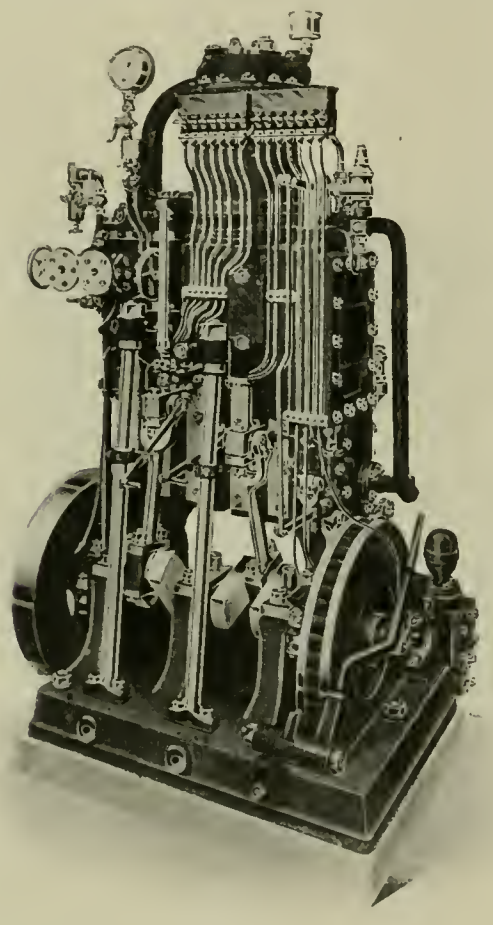
COLD STORAGE ON BOARD SHIP.

PART VI.

BY SYDNEY F. WALKER M. I. E. E.

CIRCULATING PUMPS.

Two kinds of circulating pumps are required for refrigerating apparatus, apart from the compressor, which is itself a pump—that for the condensing water, and that for the brine, where brine is employed. The sizes of the pumps and their arrangement hardly require any explanation to marine engineers. They will depend upon the quantities of water and brine to be circulated, and the sizes and lengths of the pipes through which they pass. The pumps can be driven by any convenient source of power. With small plants it is usual to mount them on the outside of the tank which forms the condenser, and to drive them from



HASLAM NAVAL REFRIGERATING SET, MOUNTED IN TANDEM.

the compressor crank shaft. With larger plant, separate arrangements may be made. It must be remembered that the metal of the brine pump becomes very cold and that the moisture in the atmosphere condenses on it and freezes.

The work done by the heat delivered to the generator in the absorption apparatus is the equivalent of the work done by the engine driving the compressor, and the economy of the system, as opposed to that of compression, turns upon this point—the relative economy of using the steam direct, and using it to drive a steam engine which in its turn drives a compressor. The heat delivered to the generator must be sufficient to convert the liquid ammonia into gas, as well as to raise the temperature of the solution, so that the gas may be expelled. A proportion of this heat is obtained from the heat delivered by the gas to the water in the absorber, in the act of solution, and the further this can be carried, the more economical must the process be.

HOW REFRIGERATING APPARATUS IS MEASURED.

In a previous part of these articles, the terms one-ton machine and six-ton machine have been used. These terms express the manner in which refrigerating apparatus is measured. A one-ton machine is one that will produce what is called a ton of refrigeration in twenty-four hours. A ton of refrigeration is the equivalent of the cooling effect that the melting of a ton of ice would produce in the same time. Ice requires, as mentioned, the abstraction of 142 heat units for every pound of water that is frozen, from and at 32 degrees F. In melting, each pound of ice will absorb 142 heat units, and a ton of ice therefore will absorb, on American measurement, 284,000 units, and on British measurement, 318,080 units—America using the simpler short ton of 2,000 pounds, while the United Kingdom uses the old-fashioned 2,240 pounds. The above figures mean, respectively, 11,833 and 13,253 units per hour. It is important to remember this latter fact.

It may happen that it is required to extract heat very rapidly. The most rapid rate for a one-ton machine is given by the above figures, the capacity of larger or smaller machines being in direct proportion. It is also important to note that a one-ton machine will not make one ton of ice in twenty-four hours. It is usually reckoned that the quantity of ice which will be made by a machine of any given size is one-half its rating. The reason is, there are losses between the refrigerating plant and the water that is being frozen, added to which work has to be done in abstracting heat from the water in reducing it to freezing point, and from the ice after it is actually frozen. The old rule holds here as everywhere—do not cut your plant too fine; and another rule which is equally true—you can afford to work closer to the rated capacity of any plant, the greater care you give it.

Practice allows a one-ton machine for a cold chamber ranging from a capacity of 800 cubic feet up to 3,000 cubic feet, a two-ton machine from 3,000 to 6,000 cubic feet, a four-ton machine from 10,000 to 20,000 cubic feet, and so on.

THE POWER REQUIRED FOR REFRIGERATING APPARATUS.

The power required varies from 0.3 horsepower per ton of refrigeration, up to 1.7 horsepower. Small plants require more power in proportion than large plants, and more power is required, usually, in hot climates than in temperate. Small plants are allowed from one horsepower up to three horsepower for a one-ton machine, the proportion falling as the size is increased. The power required increases as the condenser pressure increases, and that is one reason why more power is required in hot climates. In addition, more power is required because more water has to be circulated, when its initial temperature is higher.

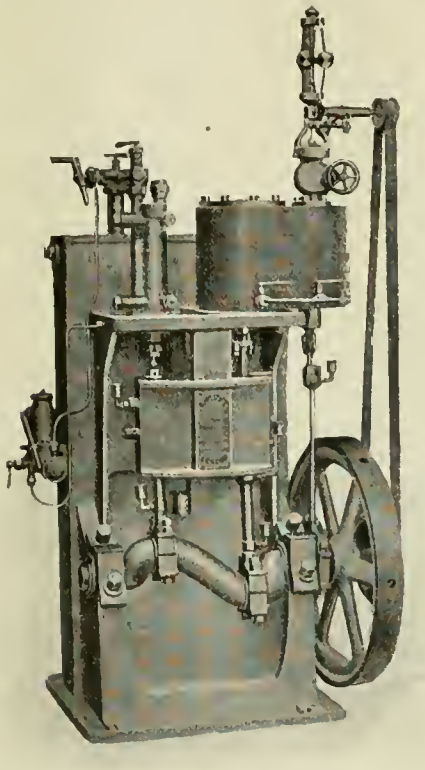
COOLING WATER.

A point that is of importance here is to note that if sea water is employed its specific heat is lower than that of pure water. It may easily have a specific heat as low as 0.95, which means that a little over 5 percent additional cooling water must be allowed. For cooling water having an initial temperature of 55 degrees F., and having its temperature raised to 80 degrees F., the following quantities of pure water are required: for the ammonia condenser, 50 gallons an hour per ton of refrigeration, and with carbonic acid about 15 percent more, according to the Linde Company's experiments; larger quantities are required, as explained, when the initial temperature is higher. Approximately, ten gallons per ton additional will be required for every five degrees increase in initial temperature, unless the final temperature can also be increased, and again larger quantities for carbonic acid.

FORMS OF APPARATUS FOR USE ON BOARD SHIP.

The apparatus that is most suitable for ship board use is the one that occupies the smallest space, provided other things are equal. Some forms of apparatus are made very compact, the casting upon which the compressor and engine are built inclosing

the condenser for the refrigerator, while the condenser for the steam engine which drives the compressor is carried overhead. The driving arrangements are also made very compact, the steam engine bed being extended at the back of the cylinder, and



WEST CARBONIC ANHYDRIDE COMPRESSOR AND CONDENSER.

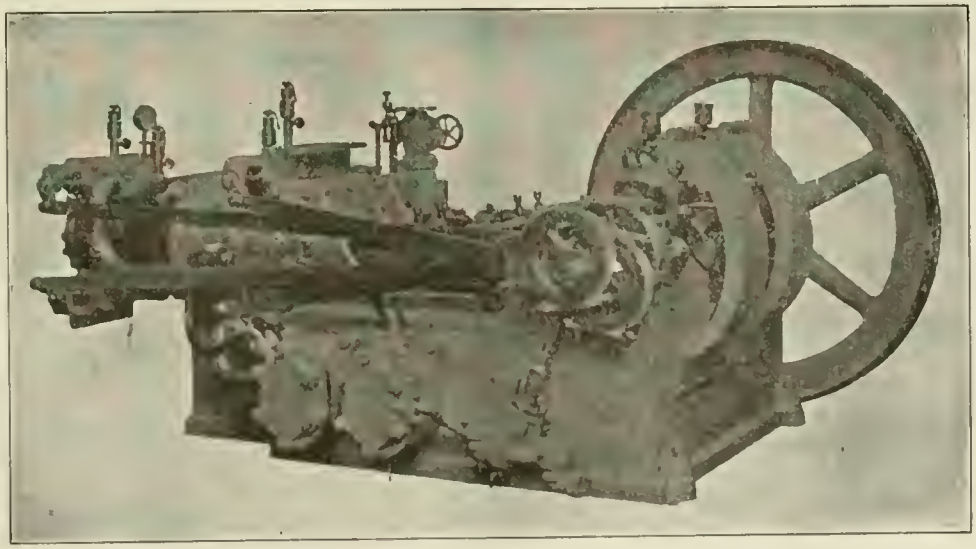
the tail rod of the piston being used as the piston rod of the compressor. A useful form of apparatus that has been fitted into some ships has two steam cylinders, mounted on one bed plate, each driving its own carbonic acid compressor by the tail rod of its piston as explained above, and each having its own steam and its own carbonic acid condenser.

are tested to a pressure several times that which they are likely to have to stand; but it is well to keep the spare bottles cool. With increased temperature the gas endeavors to expand, and if it is not able to do so, the pressure increases inside the bottles. With iron and steel it is a very difficult matter to be sure that there are no flaws, hidden away in the body of the metal, which the increased pressure would find. Also, stoppers sometimes become faulty after a time. In any case, it is a very simple matter to provide for keeping the bottles cool. A cupboard is built, large enough to take the spare bottles that are carried. It is insulated in the usual way, and has a small grid of pipes carrying the refrigerant or brine, as convenient; or it may be cooled by exposure to the current of air, or a branch of it, that is cooling the cold chamber.

COOLING MAGAZINES AND OFFICERS' AND MEN'S QUARTERS.

Trouble appears to have arisen in the British Navy over the matter of cooling the magazines. It was reported some time since that fans were put on to cool the magazines, but they produced trickling water on the walls, and so had to be abandoned. With refrigerating apparatus on board, the problem should be solved with ease. The air entering the magazine should be dried before its entrance, by one of the methods described. Probably a small grid and a small fan would do the work very well. But it must be remembered that for successful ventilation the air that is displaced must be disposed of. It is of no use trying to force fresh air into the magazine unless the air already in the magazine is carried away. There must be a complete ventilating circuit, just as there must be a complete electrical circuit, or no action can take place; but the atmosphere may form part of some ventilating circuits, just as the ground forms part of some electrical circuits.

The same remarks apply to cooling the officers' or men's quarters, or to cooling the 'tween decks, when live cattle are carried there. Putting a fan in somewhere and churning up the air will not ventilate. It may create drafts, but it will only move the air, not change it. A current of air brought down from the deck, and directed through the space to be cooled, will cool to the extent that its temperature and the quantity available allow, as explained in connection with the cooling of air for cold chambers. But where the atmospheric air is at a high temperature, especially if it is heavily charged with vapor, it has very little cooling effect. The figures given above will show this. If the air is cooled a few degrees, and dried, it will then produce a



STEAM-DRIVEN DRY AIR REFRIGERATING MACHINE, LIGHTFOOT SYSTEM.

OTHER APPLICATIONS OF REFRIGERATION ON BOARD SHIP.

One useful application of cold temperature is to keep low the temperature of the carbonic acid that is stored. The refrigerants employed are always carried in strong iron or steel bottles, which

pleasant, cooling effect on both man and beast, because, with men at any rate, nature's cooling apparatus, the evaporation of perspiration from the skin, can come into play. This evaporation can take place in a dry atmosphere, even if it is not a cool one.

SHORE END OF MUSKOGEE WHARF (L. & N. RY.) FROM WHICH AN ENGINE AND FORTY CARS OF COAL WERE LOST.

The Pensacola Hurricane.

During the night of September 26-27 a terrific West India hurricane devastated the country in the neighborhood of Pensacola, Florida, and in particular caused immense destruction to shipping in the harbor. Many ships of considerable size were beached or were damaged or pounded to pieces by striking one another after their cables had been broken or anchors dragged from the mooring grounds. Six vessels in the port proved total losses, while as many more which were driven ashore are in nearly as bad condition.

LIP BETWEEN PALAFOX AND BALEN STREET WHARVES, PENSACOLA, FLORIDA.

The German bark *Marie,* 1,022 tons, which has been abandoned, was wrecked completely by being forced from her moorings, and pounded from the stern by the Norwegian bark *Campbell,* 1,100 tons, which was also wrecked. The *Marie* was forced upon the shore and the cargo, which had been partially put aboard her, has been removed. The *Campbell* is split in halves, having broken from her mooring at the east side of Tarragona dock.

OVERTURNED FISHING SCHOONER AND WRECKED FREIGHT TRAIN.

WRECKED STEAM TUGS IN PENSACOLA HARBOR.

NORWEGIAN BARK CAMPBELL AND GERMAN SHIP MARIE.

The Norwegian ship *Inquid,* 1,260 tons, which had just started discharging a full cargo of cement imported from Hamburg, was thrown high up on the rocks, and has been completely abandoned. The ship was under charter to reload for Rio de Janeiro.

The Portuguese ship *Ferreria,* 963 tons, which was originally a British ship engaged in the coolie trade, was another total loss. The ship was fully loaded and almost ready to sail. The Norwegian ship *Avanti,* 1,831 tons, was left in a very precarious position with small chance of being saved. She was loaded and bids were asked for the removal of the cargo.

Other vessels which were badly damaged but not destroyed

GENERAL AND TYPICAL VIEW OF WHARF WRECKAGE AFTER THE STORM.

include the British ship *Canada*, 2,237 tons; Italian ship *Lena*, 1,587 tons; Norwegian bark *Hereford*, 1,524 tons; Norwegian bark *Heimdal*, 1,491 tons; and the Uraguayan bark *Iliua*, 700 tons. Our illustrations show the sort of wreckage resulting from a storm of this magnitude.

THE USE OF KEROSENE OIL IN ENGINES BUILT FOR GASOLINE.

BY H. B. MAXWELL.

The constantly increasing demand for gasoline, owing to new fields for its use being rapidly developed, has caused a steady increase in price, which makes the use of the heavier and cheaper liquid hydrocarbon fuels a matter of such importance that it has for some time past attracted the attention of engineers engaged in designing internal combustion engines. There are a number of commercial engines on the market for stationary, and a few for marine, use that are regularly built to use kerosene, but in nearly all of them the designers and inventors, as is usually the case, have used a complicated mechanism to reach the desired end.

To digress a little from the subject in hand, attention may be called to the fact that gas naphtha, running from 58 to 62 degrees Beaumé, can be used successfully in any well designed four-cycle engine, and in two-cycle engines after they have been heated up by running a short time on gasoline. A few users of gasoline engines are aware of this fact, and where so situated as to obtain it use it exclusively, and as it costs only six or seven cents per gallon, the saving is quite an item.

To use gas naphtha successfully, note must be taken of the fact that, owing to its being heavier than gasoline, it takes more air to furnish the proper amount of oxygen for complete combustion. The vaporizer or carbureter should therefore be adjusted for the heavier fuel by closing the needle valve until a properly combustible mixture is found.

With any fuel, the cooling water in the cylinder jacket should be so restricted that it leaves the jacket at a temperature of from 180 to 200 degrees Fahrenheit; with air or oil cooling, higher temperatures are desirable; in fact, with any internal combustion motor using any kind of fuel the hotter it can be run without causing preignition, or destroying the lubricant, the greater the efficiency will be. It will surprise the average user of a gas or gasoline engine to make a few tests of fuel consumption with varying temperatures of the cooling water at the outlet, as it will be found that when the water circulation is so rapid as to keep the engine cold, an appreciably greater quantity of fuel will be used than will be the case where the water is raised nearly to the boiling point before leaving the jacket.

Kerosene can be used in many engines after being warmed up on gasoline, but not economically unless some device is added to insure perfect combustion of the fuel or to aid in the better vaporization of the fuel before it reaches the combustion chamber. It has been found that by using a common mixing valve of the type shown in Figs. 1 and 2, kerosene can be used successfully.

Referring to Fig. 1, it will be noticed that the nut forming the cap to the body of the valve is tapped for a priming cup. This is to be filled with gasoline, and the engine started on this. As soon as the engine is heated up a little, open the needle valve controlling the kerosene inlet. After doing this a blue smoke will be noticed at the exhaust pipe. Then turn on the valve controlling the water supply, a little at a time, until this smoke clears away, being sure that lubricating oil is not being used in excess. This will work on most four-cycle engines using high compression.

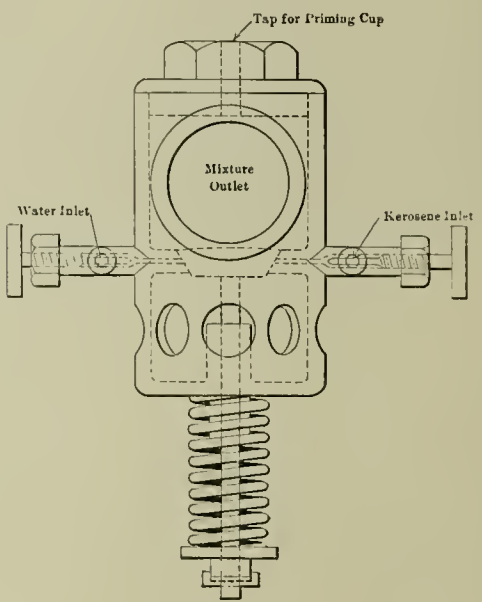


Fig. 1

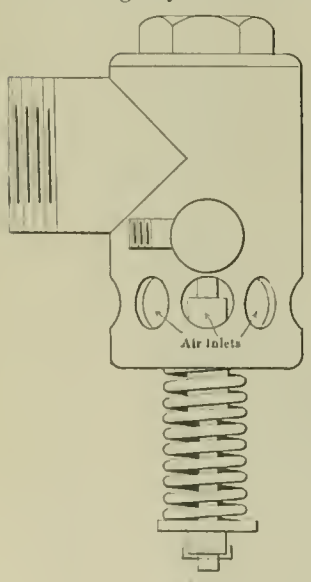


Fig. 2

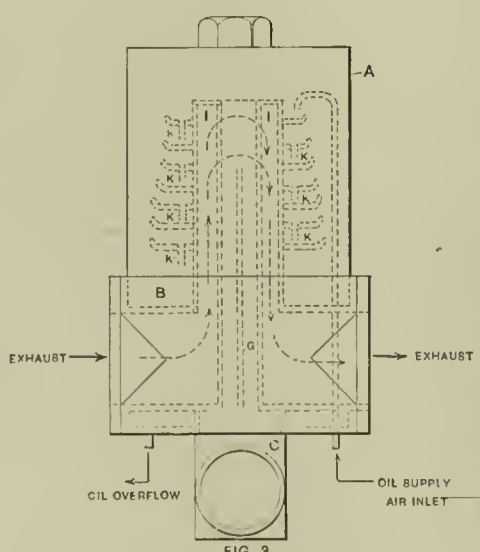


FIG. 3

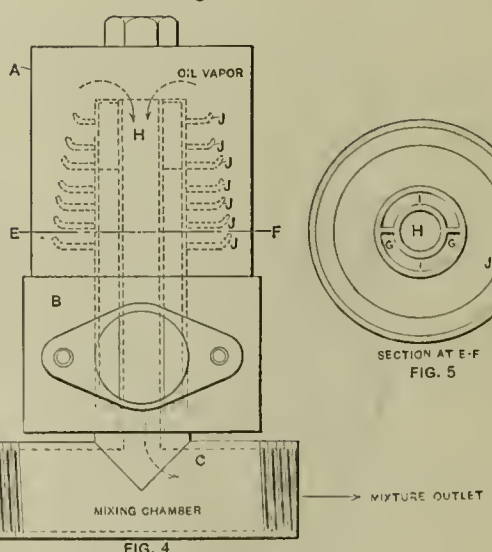


FIG. 4

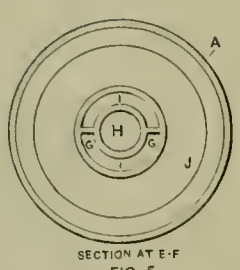


FIG. 5

KEROSENE OIL VAPORIZER

Figs. 3, 4 and 5 show an exhaust heated vaporizer that can be used with any engine. It consists of a body *B* and *C*, cast integral with the pipes and oil pans, as shown in the dotted lines, Figs. 3 and 4, and section, Fig. 5. The cap *A* screws into the body *B*, and can be readily removed to clean the pans of any tar or coke deposited from the fuel used. The oil supply may be operated by a variable stroke pump controlled by a governor, or the engine can be controlled by throttling the mixture

between the vaporizer and the intake valve. There must be an air regulator attached to the mixture chamber *C* at the end opposite from the end used to convey the mixture to the engine.

The exhaust enters the T-shaped pipe *I I* and impinges against the pipe *H* and the guides *G G*, giving the exhaust gases

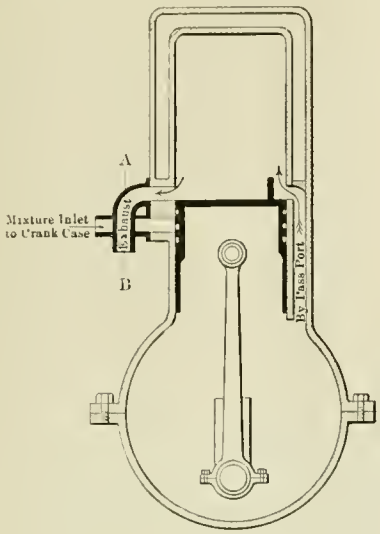


Fig. 6

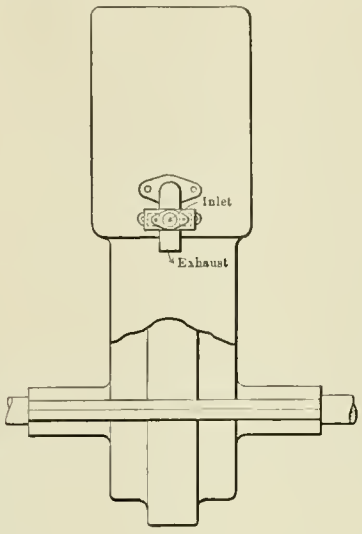
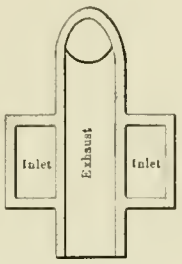


Fig. 7



Enlarged Section at A.B.
Fig. 8

the course shown by dotted arrows in Fig. 3. This imparts part of the heat of the exhaust gases to the walls of the pipe *I I* and the pans *J J*. It will be noticed that the overflow pipes *K K* from each pan to the one next below it bring the fuel not vaporized by the first hot surface into contact with other hot pans, to complete the vaporization. Any overflow is taken care of by the outlet at lower left hand side of Fig. 3. The oil, gas or vapor flows down pipe *H* to the chamber *C*, where it is mixed with the proper amount of air to furnish the correct mixture.

Figs. 6, 7 and 8 show a device designed by the writer, and *not* patented. Referring to Fig. 6, it will be noticed that the exhaust and intake pipes are cast integral. The inlet from carbureter at the left opens directly against the hot walls of the exhaust pipe, and as shown in Fig. 8, divides and passes around the exhaust pipe and enters the port to the crank case.

This works so well that it is now being applied to a two-cycle air cooled engine, with every confidence that it will solve the problem for a cheap and reliable motor. Of course, to start a two-cycle engine with this device, it must be primed with gasoline, the priming cup being located on top of the cylinder; or the combination exhaust and inlet pipe could be heated with a torch.

The Fast Launch Svip.

Built and engined by John I. Thornycroft & Company, Limited, Chiswick, London, W., the *Svip* has a length of 35 feet, a beam of 5 feet 9 inches, and a draft of 1 foot 6 inches.

The boat is carvel built of cedar, bright varnished inside and out. The engines are two 24-horsepower 4-cylinder Thornycroft motors, driving twin screws, the ignition being the standard low-tension magneto. The exhaust is carried through a muffler fitted in a neat funnel, which is fixed to a baffle plate immediately over the engines.

The boat is intended for fast cruising, has comfortable seating accommodation for 12 to 16 people, and can be adapted to stand a very fair sea. A feature of the boat is the sliding hood, which can be collapsed and rolled up at the forward end when desired.

THE THORNYCROFT MOTOR BOAT SVIP, ON THE THAMES.

The boat attained a speed of 20¾ miles per hour on the first occasion on which the engines were started up, a performance which may be considered very satisfactory. The builders guaranteed the boat (under a penalty) to be capable of a speed of 20.5 miles per hour with two persons on board. On the official trial the boat ran six times over the measured mile, with and against the tide, at an average speed of 21.2 miles per hour, three persons being carried. It will be seen, therefore, that the boat exceeded its contract speed by nearly 0.7 mile per hour, with an extra passenger on board.

Personal.

Frederick A. Goetze has been appointed dean of the School of Applied Science of Columbia University, to take effect January 1.

A NEW TORSION METER, FOR MEASURING THE POWER OF MARINE STEAM TURBINES.

BY FRANK C. PERKINS.

Torsion meters are particularly valuable in steam turbine work, as it is impossible with this form of motive power to take indicator cards, as with reciprocating engines. By means of this instrument the power developed and transmitted from a steam turbine can be ascertained, and accuracy of 99 percent obtained in the readings. The instrument has been utilized to great advantage on a number of the turbine steamers, the recording box being placed in the cabin where there is very little noise and the sound of the telephone receiver is distinctly heard. Recording machines have also been devised and installed with a moving strip of paper, a pen which reports the number of revolutions by means of electric contacts, another pen connected with the bridge so as to take the time on the mile, and a third pen marking the half seconds from a standard chronometer.

The accompanying illustrations indicate the construction and arrangement of the new torsion indicator constructed at Glasgow, Scotland, by Kelvin and James White, Limited, after designs of Charles Henry Johnson, and Archibald Denny. One view shows one of the instruments installed on a turbine steamer, the disk being fixed at one end of the center shaft; the disk fixed to the remaining shafts and to the other end of this shaft are similar. Another illustration shows the recording box, while a third shows two inductors of a somewhat different construction of torsion meter, the indicator *A* consisting of a thin soft iron core wound with insulated wire, and arranged on a base provided for the purpose, while the inductor *B* is a similar core wound with insulated wire, and mounted on a slider on a quadrant-shaped guide in such a way that by turning a handwheel the slider carrying the core may be moved along the guide either forward or backward as desired.

The telephone receiver is placed in a circuit with the inductors, which are placed beneath a wheel carrying a magnet. In order to take a reading the handwheel is moved until silence is obtained in the telephone receiver. This adjustment is noted, and indicates the amount of torsion of the shaft. This form of torsion meter is intended for low speeds, and can be utilized to advantage for measuring the torsion of shafts of vertical or horizontal reciprocating engines.

On account of the uneven turning moment of steam engines, the torsion of this kind of shafting varies during a single revolution. For this reason six magnets are utilized on each wheel instead of one, these magnets being equidistant from the circumference of the wheel, and on a different parallel plane, while six separate windings are arranged on each conductor, and a switch is provided by means of which any pair of windings on the two inductors can be simultaneously connected in the circuit with the receiver.

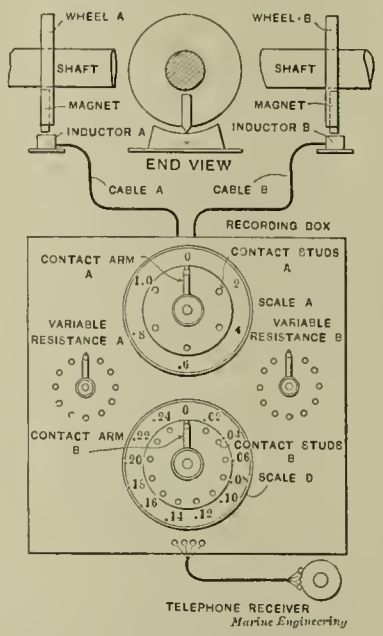


FIG. 1.—DIAGRAM OF THE ELECTRIC CIRCUIT.

Resistances are arranged for adjusting the strength of the induced current, and in this manner the torsion at six different points can be measured easily, and therefrom the mean torsion for complete revolution can be noted. It may be stated that on a test with a reciprocating engine which had a turning moment of considerable variation it was noted that with six magnets the greatest error was not over 4 percent, and when working out a polar diagram of torque the error was not more than 1 percent, with the magnets suitably arranged on the wheel.

One of the special features noticed in this instrument is the absence of rubbing contact, thus avoiding wear and tear. These instruments are particularly well adapted for work on shipboard, making it possible to take frequent readings of the power, and note with accuracy any loss of efficiency. For testing steam

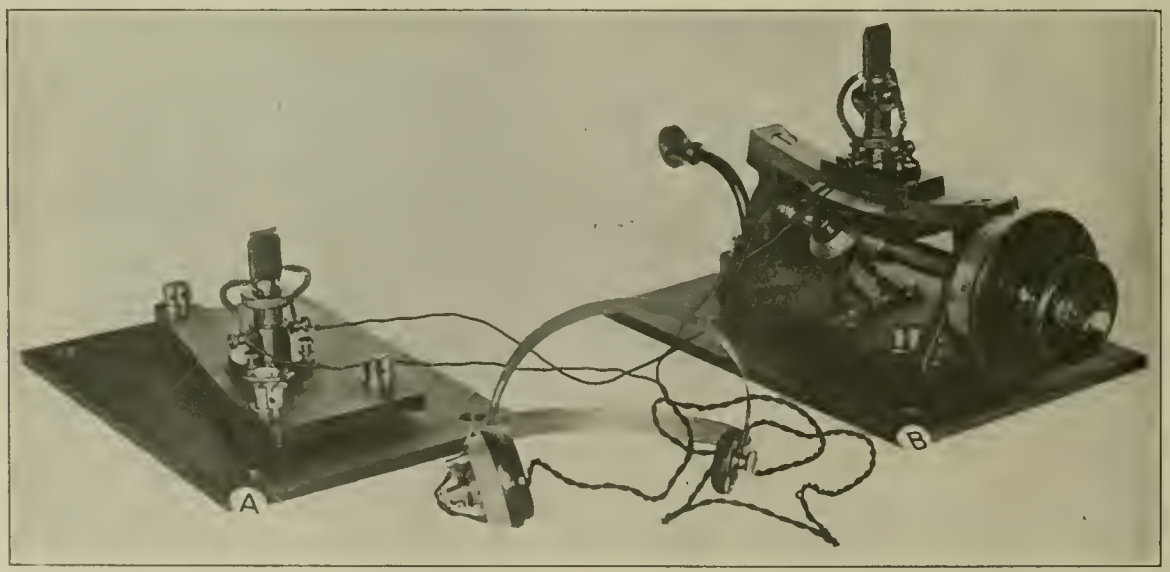


FIG. 2.—THE TELEPHONIC RECEIVING MECHANISM OF THE TORSION METER.

turbines they are of great value, and have given excellent satisfaction.

The diagram shows the arrangement of the torsion meter when connected with turbine driven shafting. Two light wheels, *A* and *B*, similar to that shown in Fig. 1, are fastened to the shaft at proper distances apart, and a permanent magnet mounted on each wheel in such a manner that the projecting pole produces a dense and definite magnetic field at the point, by being constructed in the shape of a *V*. There are two inductors, *A* and *B*, set concentrically with the wheels and shaft, and just below the magnets. Each of these inductors consists of a quadrant-shaped piece of soft iron mounted on a gun metal stand provided with leveling screws. A number of separate windings are arranged on each piece of iron, a suitable number of turns per unit of circumferential length of iron being used.

A recording box of the type shown in Fig. 3 is used, having two series of contact studs, *a* and *b*, which are marked with proper scales, and two contact arms *A* and *B*, so that electrical connection can be made with any stud of a series and with its contact arm, there being in series *A* a stud for every separate winding in the inductor *A*, and similarly for every separate

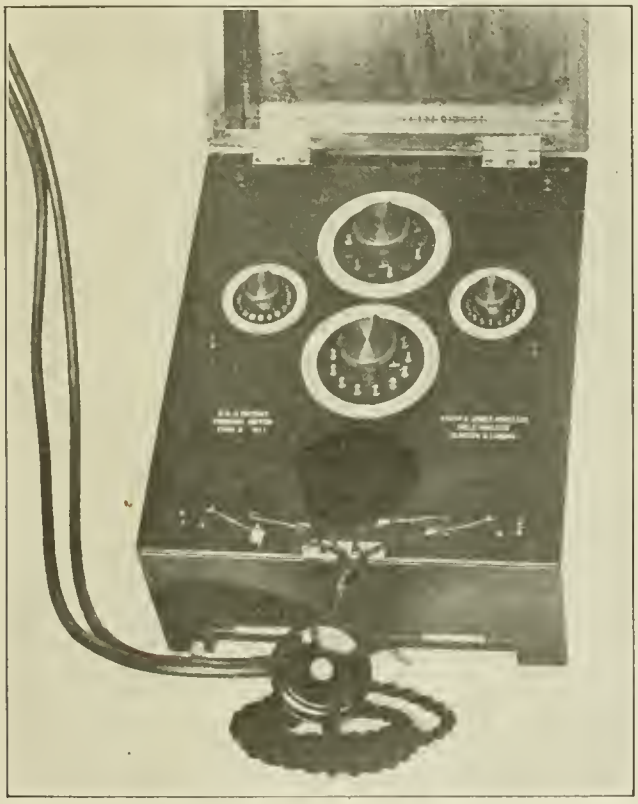


FIG. 3.—RECORDING BOX SHOWN IN FIG. 1.

winding in the inductor *B* there is a stud in series *B* of the recording box. Each stud is connected to its own particular winding by means of an independent wire, and all the wires are contained in the multiple cables *B* and *A* connected with the inductors *B* and *A* respectively. There is a variable resistance provided for each of these two circuits, and one winding of a differential telephone receiver. There are six equal parts and six separate windings in the inductor *A*, and the scale *A* is therefore divided into six parts, there being six studs in the *A* series. It will be noted that the length of the five subdivisions of the scale represents the circumferential length occupied by all the windings on the inductor, this being about 0.2 inch, each subdivision being the distance between windings.

There are fourteen equal parts to the scale *B*, as there are fourteen independent windings on this inductor, and in the series *B* fourteen studs, with a distance between windings of 0.02 inch. The inductor at the turbine end of the shaft has its wheel so set that its magnet is above one or the other of the two end windings in the end inductor. When the shaft rotates without transmitting any power a current of electricity is generated in the end winding of each inductor, and these two separate currents traverse their own circuits in passing from the inductor winding to the studs, and then through the contact

FIG. 4.—ANGLE MEASURING INSTRUMENT ON SHAFT.

arms and resistances, as well as to the telephone receivers and in returning to the inductors.

The receiver windings are so connected that the effects of the independent currents are in opposition, and neutralize each other at the receiver when the two current strengths are the same. With the variable resistances the currents can be made equal in strength, and in this manner when the shaft transmits no power and there is no torsion there will be no sound in the receiver. As soon as the shaft begins to transmit power, and there is a twist or torsion, there will be a loud ticking sound noted in the receiver, as the currents no longer neutralize each other. It is then necessary to move the contact arm *B* from one stud to another until silence is again obtained in the receiver. By noting the reading opposite the scale *B*, the angle of torsion of the shaft will be noted. The scale reading represents the displacement of one magnet with regard to the other, due to the torsion of the shaft.

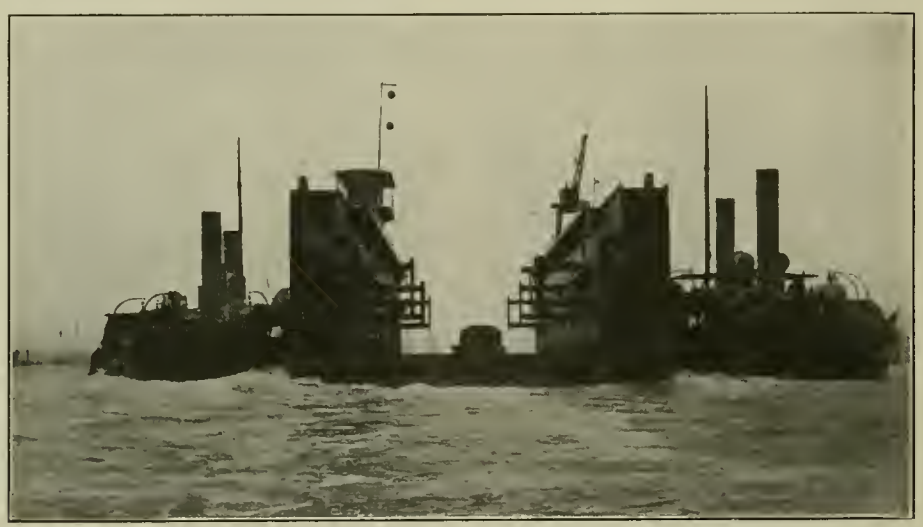
The National Association of Engine and Boat Manufacturers announces the National Motor Boat Show to be held in Madison Square Garden, New York, from February 19 to 26 inclusive. It was decided last year that this show was to be exclusively a motor boat show, the sportsmen element being divorced from the motor boat element, and being the subject of a separate show. It was also decided, on account of the great demands made upon the space within the garden, and particularly upon the main floor, to dispense with the tank, which has been so prominent a feature of the last two shows. Arrangements are made for the operation by illuminating gas of internal combustion motors.

Launch of a Floating Dock.

The following is a general description of the new floating dock built by Messrs. Vickers, Sons and Maxim, Limited, for the British Admiralty, for use at Haslar, and which was launched recently.

The over all dimensions of the dock are: length, 250 feet; width, 50 feet 6 inches; depth of pontoon at center, 6 feet 4 inches; length of side walls, 200 feet; height of side walls above lower edge of pontoon, 22 feet 6 inches; height of side walls and pontoon, 28 feet. The hull is constructed throughout of open hearth mild Siemens Martin steel.

The dock is required to lift a vessel displacing 500 tons and of a maximum draught of 10 feet within a space of one hour. The dock, however, has a net lifting power of 1,000 tons, and is capable of docking a vessel having a draught of 16 feet. In the center of the starboard wall, a two-storied motor house with galleries is fitted, to contain on the ground floor the electric motors and starting resistances, on the second floor immediately above, the valve levers and switch board. A three-ton hand crane mounted on a traveling under carriage is placed on the starboard wall, and on each wall of the dock an electric capstan is fitted. In addition to the usual keel blocks, three double mechanical side shores are provided in each wall. The pumping gear is worked by electric motors. The dock is lighted throughout by electricity, and is fitted up with all the usual appliances.



NEW FLOATING DOCK FOR SUBMARINES; PORTSMOUTH HARBOR, ENGLAND.

Developments in Warship Design.

At the eleventh annual meeting of Sir W. G. Armstrong, Whitworth & Company of Newcastle-on-Tyne, England, which was held September 28, 1906, the chairman of the Board of Directors called attention to recent battleships and armored cruisers designed in England, the main object having been to increase the power of the armament and, at the same time, to simplify its application. In the most recent designs there have been placed only two calibers of guns, aside from machine guns, consisting of powerful armor-piercing weapons and of quick firing guns of greater power than formerly used, and fitted for the purpose of keeping away hostile torpedo craft. The principal armament in recent designs consists of from 8 to 16 armor-piercing guns, and there are indications that the company in question would engage to increase the number to 20, with a corresponding increase in the displacement of the vessel. The secondary armament in vessels designed at this works was placed at from 16 to 24 quick firing guns of 4-inch or 4.7-inch caliber, the number and size depending upon the size and character of the vessel under construction.

Another question of very great importance is that of speed. The old advantage of the weather-gage has taken a new form known as speed-gage. Each of these items enables the possessor to accept or decline combat at will, depending upon the particular situation existing at the moment. The use of turbine machinery has enabled shipbuilders to give to warships of great power a higher speed than has heretofore been the case, and thus to obtain all the advantages inherent in superior speed.

Steamer for Cuba.

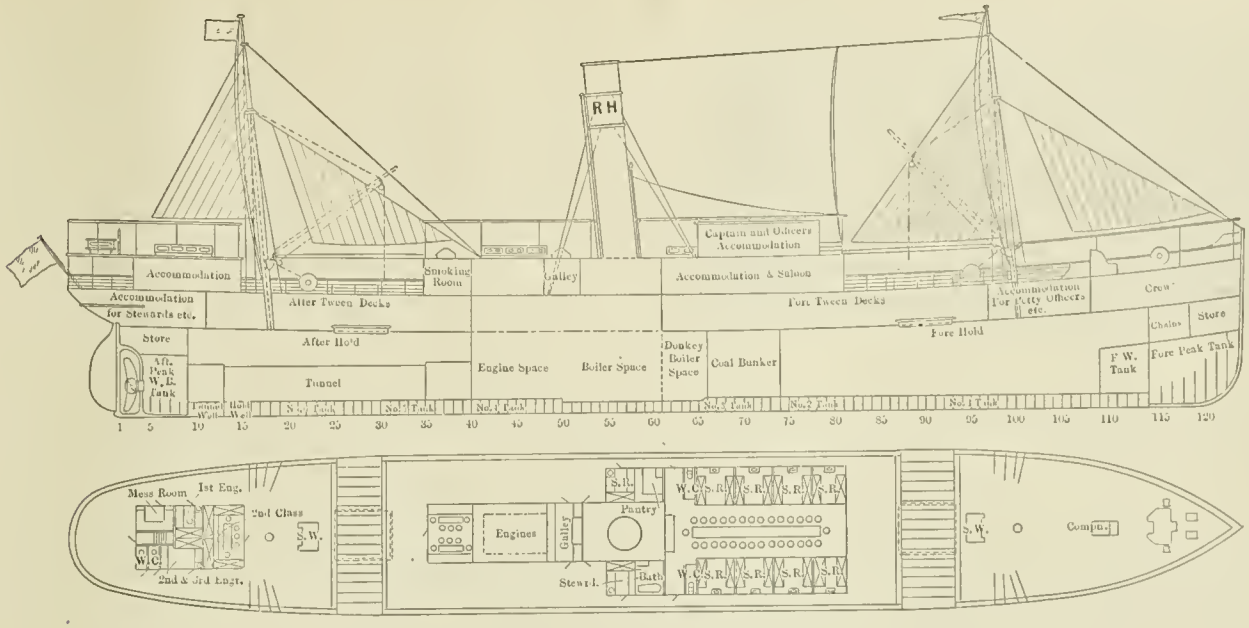
An interesting vessel for Havana has been launched from the shipbuilding yard of William Hamilton & Company, Limited, Port Glasgow, in the shape of a steel screw passenger and cargo vessel of about 1,450 tons gross, built to the order of Sobrinos de Herrara Societe en la Ciudad de Habana, for their Cuban coastal trade. This vessel is 235 feet long, 35 feet beam and has a depth of 24 feet to the awning deck; and she has been built under special survey of the British Corporation for their highest class.

Accommodation is provided for 33 first-class passengers at each side of a large teak deckhouse placed on the awning deck forward of the boiler casing. The cabin enters off the dining saloon, which is situated between the two rows of staterooms. The dining saloon is arranged to seat 33 persons, and is tastefully decorated, well lighted from skylights overhead, and ventilated by means of electric fans. A handsome smoking room is fixed aft of the engine casing.

Second-class accommodation is arranged in the fore end of a large deckhouse on the aft end of the awning deck, and accommodation for captain, officers and engineers is provided at the after part of the second-class accommodation. In a deckhouse on top of saloon house deck are the chartroom and steering house. The accommodation for crew is forward under the awning deck, and for servants, stewards, etc., at the after end under the awning deck.

The 'tween deck is lighted throughout by sidelights and is sheathed with pitch pine so that it may be used for carrying cattle. The awning deck is of teak. For the quick handling of cargo, each hatch is provided with a powerful steam winch and three derricks. The vessel is lighted throughout by electricity, and has a powerful steam windlass and steering gear.

The *Habana* is designed to steam 11½ knots in service, and is fitted with triple expansion surface condensing engines constructed by Muir and Houston, of Glasgow, with cylinders 19, 31 and 51 inches in diameter and stroke of 36 inches; and two boilers 14



INBOARD PROFILE AND ACCOMMODATION PLAN OF NEW CUBAN STEAMER HABANA.

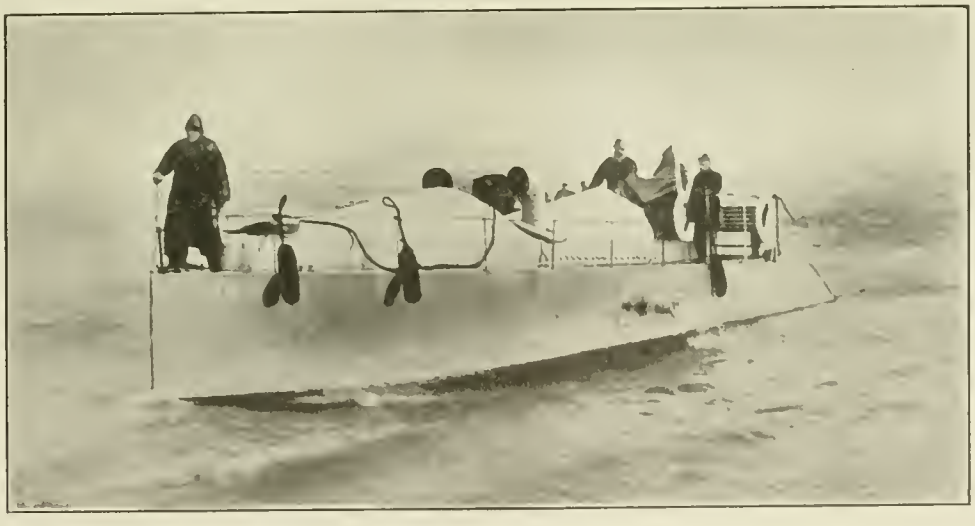
feet diameter by 10 feet 6 inches long, and 180 pounds working pressure, natural draft.

BENJAMIN TAYLOR.

A Motor Torpedo Boat.

The original idea in the construction of fleets of torpedo boats was the provision of a mosquito squadron consisting of large numbers of small and inexpensive vessels, exposing a small area to gunfire, and having a high speed to enable them to successfully attack larger vessels. Developments, however, particularly in the line of increased speed, have gradually brought about an increase in size, until the latest vessels of the torpedo type, or destroyer class, displace nearly one thousand tons, as compared with forty or fifty tons in the earlier types. As the cost has increased more than proportionately with the displacement, the number of vessels built has correspondingly decreased, and it has long been a question whether better protective results might not have been attained with a larger number of smaller vessels.

To meet this condition, Messrs. Yarrow & Company have brought out a torpedo boat propelled by internal combustion engines operating three propellers. The boat is 60 feet long with a beam of 9 feet, and displaces only 8 tons, which makes it readily transportable by rail from one point to another, thus following what might be called an "inside route" of communication. The structure is very light, and the engines are of sufficient power to give the boat a speed of 24 knots when carrying a load of 3 tons in the shape of torpedoes and fuel. The latter is carried in a special tank which does not form any part of the structure of the hull, while the armament may consist of either one torpedo in a revolving tube or two in drop gear at the side.



THE YARROW MOTOR-DRIVEN TORPEDO BOAT ON HER TRIALS.

It is estimated that a steam driven boat of the same size, and carrying the same load, could be provided with machinery capable of giving her a speed of only 18 knots. It is, moreover, estimated that the radius of action of such a steam-driven boat, on one ton of fuel, would be sixty miles, as compared with three hundred miles for the present craft. Vibration is said to be very slight, even at full speed of the engine (1,000 revolutions per minute). It is stated that three hundred and fifty of these vessels could be built for the price of one *Dreadnought*.

INTERNATIONAL MARINE ENGINEERING

Published Monthly at
17 Battery Place - - New York
By MARINE ENGINEERING, INCORPORATED
Christopher St., Finsbury Square, London, E. C.

TERMS OF SUBSCRIPTION

	Per Year	Per Copy
United States, Canada and Mexico	$2.00	20 cents
Great Britain and Ireland	10/6	1/
Other countries in the Postal Union	10/6	1/

Entered at New York Post Office as second-class matter.
Copyright, 1906, by Marine Engineering, Inc., New York.
INTERNATIONAL MARINE ENGINEERING is registered in the United States Patent Office.
Copyright in Great Britain; entered at Stationers' Hall, London.

Notice to Advertisers.

Changes to be made in copy, or in orders for advertisements, must be in our hands not later than the 5th of the month, to insure the carrying out of such instructions in the issue of the month following. If proof is to be submitted, copy must be in our hands not later than the 1st of the month.

The edition of this issue comprises 6,000 copies. We have no free list, accept no return copies and issue only enough to supply the regular demand.

Marine Steam Turbines.

The subject of the steam turbine as applied to marine uses is becoming one of ever increasing importance. Our present number contains an unusually large quantity of material on this subject, including the reprint of a paper read by Mr. Parsons himself; accounts of the trials of the British battleship *Dreadnought,* equipped with four Parsons turbines; a description of the German merchant steamer *Kaiser,* equipped with Curtis turbines; a comparison between Curtis marine turbines and reciprocating engines; and a description of an instrument and method for measuring the power of steam turbines when applied to ship propulsion.

The wonderful flexibility of this instrument of propulsion was briefly mentioned in our comment last month in connection with the powering of the new British battleships of the *Invincible* class, in which it is expected to attain an extremely high speed, with a large margin of power. This flexibility receives further notice in connection with the Curtis turbine illustrated on page 481 of this issue, in the comparison there made. Practically the only difference between that turbine of eight thousand horsepower and the smaller one of four thousand horsepower applied to the Southern Pacific steamer *Creole* is in the number of nozzles through which steam is admitted, the pressure of the steam at admission, and the resulting number of revolutions per minute of the shaft. The rotors and casings of the two turbines are identical, not only in design but in dimensions, yet in the one case, due to a difference in the conditions of use of the steam, the power is exactly double that in the other.

It is difficult to know in any given case just what power may be expected of such an instrument. So much depends upon the boiler equipment, and more particularly upon the capacity of the boilers to furnish any quantity of steam which may be utilized by the prime mover, that the ultimate power seems to be partially independent of the size of the latter. The Editor remembers having tested a steam turbine rated at two hundred horsepower; but which, on being given a larger amount of steam than that for which it was designed, was operated at as much as 350 horsepower. This is right in line with the relation between the turbines of the *Salem* and those of the *Creole.* It also serves to illustrate the point brought out last month, in connection with the possibility of developing in the *Invincible* a power exceeding by ten thousand horsepower that for which the turbines have been designed.

Heretofore, tests of marine steam turbines have been figured out on a basis, a large proportion of which was estimate or approximation. This was due to the fact that the turbine is not fitted for the taking of indicator cards such as may be obtained from any piston engine. Devices now in use, however, such as that described on pages 488 and 489, afford a ready means of obtaining accurate readings of the power actually transmitted by the turbine. This method depends, of course, upon the constancy of the elasticity of the material of which the shafting is composed, but for all engineering purposes this elasticity is sufficiently constant to make the indications of the torsion meter thoroughly reliable to a degree of accuracy beyond which it is unnecessary to go.

One point in which indications of this sort differ from those obtained by the indicator cards of a reciprocating engine is, that the latter show the entire power exerted by the engine, both in overcoming its own internal and external friction, and in doing the useful work for which it was designed. With the turbine indications, on the other hand, the internal friction of the machine is absolutely eliminated, and the power, as measured, is the net power transmitted to the shaft for the purpose of doing useful work. The difference between the two is one of varying magnitude, some engines having been sufficiently well designed, and well operated, to reduce the engine friction to a figure as low as three or four percent. It is unusual, however, to get this below seven percent, and frequently from twelve to fifteen percent has to be accepted as a working condition. There is thus no direct comparison possible between figures given for a reciprocating engine tested in the usual manner, and those obtained from the indications of a torsion meter as applied to the steam turbine engaged in marine propulsion. When a reciprocating engine, however, is tested through the intermediation of an absorption or transmission brake, or dynamometer, the results so

obtained are strictly comparable with those obtained from the torsion meter.

In comparing coal or steam consumption figures, as between the two types of prime movers, account must necessarily be taken of this fact of the discrepancy in the results, and proper allowance made for the difference. For instance, the fuel consumption of the *Dreadnought* at full power figured out at 1.51 pounds per horsepower per hour. This, it will be noted, is based on the developed horsepower and, assuming 9 percent engine friction for the purpose of illustration, the coal consumption per "indicated" horsepower per hour would be only 1.36 pounds. This is a figure which will be recognized to be extremely good, and one which very few steam engines of any type have ever surpassed. In the designing of machinery for ocean liners and freighters, it is usual to assume that the conditions will be such as to call for an expenditure of 1.6 or 1.7 pounds of coal per indicated horsepower per hour, and this under conditions most favorable to the development of power at the greatest economy. In warship practice it is not at all unusual for the consumtion to figure out above 2 pounds per horsepower hour, and in many cases it is more than 2.5 pounds. These comparisons will suffice to illustrate the excellence of the results obtained upon the *Dreadnought.*

The number of turbine propelled vessels is increasing very rapidly, not only in the United States and in England, but also on the continent of Europe. It is fortunate, for the interests of marine engineering and naval architecture in general, that developments along this line are proceeding from several points of view at once. In England the only type of turbine used in this development is the Parsons. On the continent of Europe several types are being developed, the Rateau in France, the Riedler-Stumpf and Curtis in Germany, and a modification of the Parsons turbine also in Germany.

In the United States, the Curtis turbine is distinctively the American type, but the developments of the Parsons type are being fitted to vessels by two separate concerns working along independent lines, and achieving results in different ways. It may be said that neither of these developments of the Parsons turbine is exactly the same as the developments taking place in England; although, of course, both are founded upon the same basic principles, and the general outline of the results is identical. It is in the small innovations and alterations in the design and construction of such a device that the strength of the future lies with regard to the ultimate development of the system, and it is for this reason that we count it most fortunate to have this development proceeding from the minds of so many different engineers at the same time.

Internal Combustion Engines.

Following up a development of the motor boat engine in connection with the use in that engine of some fuel other than gasoline, we presented in our July number a paper covering the use of denaturized alcohol in the explosive engine, showing what changes were necessary in the design and operation of the engines in order to make the change in fuel effective. It is found that the principal change in the construction is in the carburetor, where the mixing takes place between the fuel vapor and the air with which it is diluted before being admitted to the cylinder. The use of alcohol has been found to require in the engine some pre-heating of the cylinder before operation becomes successful. This is usually done by means of a priming charge of gasoline, upon which the engine is operated for a few revolutions, or until the cylinder becomes sufficiently heated to make the alcohol take care of its work in proper manner.

In another column we present another paper, covering the use of kerosene in this same form of prime mover, and it has been found that the same conditions governing the use of alcohol in a gasoline engine obtain with respect to the use of kerosene in the same engine.

The price of gasoline has been increasing with the steadily growing demand for it for fuel purposes, due to the large multiplication of engines in motor boats and automobiles. It is largely with a view to obtaining a cheaper fuel, or, at any rate, to keeping the price of the fuel down to the lowest possible point, that the developments have proceeded, looking to the utilization of other fuels in the explosion engine. It is for this reason that the two papers above mentioned are especially valuable to engineers engaged in the designing or operation of such engines, and it is expected that, as developments in design proceed, it will become easy to change an engine from any one of these fuels to any other, without delay or stoppage due to making the transition. This state of affairs is much to be hoped for, because it will largely increase the sphere of influence of the internal combustion engine, and render it a much more flexible instrument for the production of power than is at present the case.

The Naval Architects' Meeting.

Seven groups of papers are included in the list of fifteen read at the 1906 convention of the Society of Naval Architects and Marine Engineers, there being four papers on model experimental tanks and their application; four on developments in warship design; two on fireproof steamers; two on yacht design and powering; and one each on speed trials, coaling at sea and dry-dock pumping plants. All of the papers are of importance and interest, and should command the attention of all students of marine construction, be they engaged in naval or mercantile work. But best of all was the opportunity presented by the meeting for experts to "get together" and discuss the various papers, bringing out the strong points of each, and submitting the subjects presented to a rigid and illuminating analysis. It is this contact of intellect which furnishes the highest value of such a society. The papers could well be printed in any place, but the discussions require in general the concurrent presence of numbers of master minds.

ABSTRACT FROM RULES FOR RIVETING NAVAL VESSELS.

BUREAU OF CONSTRUCTION AND REPAIR U. S. NAVY DEPARTMENT.

ARRANGED BY HARRISON S. TAFT.

1. All rivet holes through material 1 inch or more in thickness should be drilled, or, if punched, should afterwards be reamed to finished size. The increase in diameter of hole due to reaming should be equal to at least one-eighth the thickness of the material. In punching, where possible, holes will be punched from the side which will form the faying surface.

2. Great care must be taken in punching to prevent holes from coming unfair. Any unfair hole must be reamed out before riveting, and a rivet suitable to the increased size of hole inserted.

3. Counter sinking must be carefully done, following the rules for angle of countersink given on sheet I. Holes for countersunk heads and points will be countersunk through the plate or shape to a depth corresponding as nearly as possible to the dimension "B" given on plate 1 for the size and type of rivet to be used. In cases where such a depth would extend through the plate, the countersink should be carried to within 1/32 of the bottom.

4. Rivets less than ⅜-inch diameter should be driven cold. In torpedo-boat work rivets up to 7/16-inch, inclusive, may be driven cold, at the discretion of the Superintending Naval Constructor. Power riveting is to be preferred for torpedo-boat work.

5. Type of Rivets.

1. Wherever practicable, the pan-head rivet will be used, with countersunk points where flush work is required, button or snap points for finished appearance or where rivets are closed by power, and hammered or mashed points elsewhere. Where points are made with a snap tool, or where riveting by power is employed, care will be taken that the points are properly centered.

2. Care must be taken that snap points are not reduced from the standard sizes by grinding down tools that have been chipped or burred. All pan-head rivets not less than ½-inch diameter for punched holes should be coned under head, as shown on sheet 1, the rule for punching from the faying surface of plate being carefully observed. If, however, the practice of punching the holes small and reaming to size by power be employed, the coning under head may be omitted.

6. Diameter of Rivets.

TABLE 1. DIAMETER OF RIVETS.

	Weight of Plates in lbs.	Diameters	
		Rivets	Rivet Holes
Ship Work.	Up to 3 lbs. exclusive	1/4	9/32
	3 lbs. to 6 lbs. exclusive	3/8	7/16
	6 lbs. inclusive to 8 lbs. exclusive	1/2	9/16
	8 lbs. inclusive to 13 lbs. exclusive	5/8	11/16
	13 lbs. inclusive to 20 lbs. exclusive	3/4	13/16
	20 lbs. inclusive to 30 lbs. exclusive	7/8	15/16
	30 lbs. inclusive to 40 lbs. exclusive	1	1 1/16
	40 lbs. inclusive to 51 lbs. exclusive	1 1/8	1 7/32
	51 lbs. and above	1 1/4	1 11/32
Torpedo Boat Work	Up to 3 lbs. exclusive	1/4	9/32
	3 lbs. to 6 lbs. exclusive	5/16	11/32
	6 lbs. to 7½ lbs. exclusive	3/8	7/16
	7½ lbs. to 9 lbs. exclusive	7/16	1/2
	9 lbs. to 11 lbs. exclusive	1/2	9/16
	11 lbs. to 13 lbs. exclusive	5/8	11/16

NOTE.—The sizes of flanges of angles to which plates are connected in torpedo boat work may sometimes be such as to require a reduction in the size of rivet to secure satisfactory workmanship.

In cases where rivets connect plates of different thicknesses together, the size of rivet indicated for the greater thickness, with corresponding spacing, will be used where strength is required, and that indicated for the lesser thickness where water-tightness is a special consideration, always provided that the greater thickness is not more than double the lesser.

7. Tap Rivets.

Where tap rivets must be used they should be ⅛-inch larger than the corresponding ordinary rivets for the same thickness, excepting taps into heavy forgings or castings, such as stem and stern posts, which should be ¼-inch larger. Where strength is required tap rivets must penetrate *not less* than 1 diameter, and should penetrate 1½ diameters where the thickness of metal will allow it.

8. Spacing of Rivets.

1. Where the spacing given in Table No. 2 can not be followed exactly, as will generally be the case, the aim will be to make the spacing a trifle closer (as necessary in the case of heavier plating) and a trifle farther apart (as necessary in the case of lighter plating), the division between "lighter" and "heavier" plating coming at about 7½-pound plates for single riveting, at about 15-pound plates for double riveting, and at about 25-pound plates for treble riveting.

2. Where the above distinctions are considered too complicated for yard work, the general rule will be to space a trifle closer, in all cases, as necessary for equal spacing.

TABLE 2.—SPACING OF RIVETS.

Connection.	Number of diameters from center to center.
Single-riveted seams and butts	3½
Double-riveted butt laps and butt straps	4
Treble-riveted butt laps	4½
Treble-riveted butt straps, with alternate rivets in third row omitted	4
Longitudinal seams of plating required to be water-tight (excepting single-riveted seams specified in item 1)	4½
Connections of transverse frames not water-tight to outside plating	8
Connections of deck plating to beams; of non-water-tight longitudinals to outside plating; of the angles and stiffeners to bulkheads when entirely above the water line, and in general where special strength is not required	8
Connections of floor plates, brackets, lightened intercostals, etc., to clips and angles; of the vertical keel angles to the flat and vertical keel plates and to the flat keelson plates beyond the limits of double bottom, provided water-tightness is not required	7
Connections of angles and other stiffeners to bulkheads at or below the water line; of boiler and engine bearings and foundations generally	6
Connections of inner-bottom plating to all frames and longitudinals	5
Connections of angles of water-tight frames and longitudinals to all plating, and in general where water-tightness is required between shapes and plates	5
Angles and other stiffeners to bulkheads forming supports to turrets, barbettes, connections of armor-shelf angles to plating, etc.	5
Connections between staple angles of water-tight floors and the floor plates	4½
In special cases of intercostals, beam ends, etc., where strength is required in connections of limited extent, and in all other exceptional cases, spacing to be as required by circumstances, except that the rivets in the same line should never be spaced less than	3

9. Type of Riveting.

When strength is required in laps and butted connections of plating, with the spacing indicated above, single riveting is suitable only for plating under 12½ pounds and double riveting for plating under 25 pounds. For maximum strength in connections of plating above 30 pounds it will generally be found that quadruple riveting is required.

10. Single Straps.

Single butt straps and edge strips, when single or double riveted, should be of the same thickness as the plates connected, and where the plates connected are of different thickness they should be of the same thickness as the lighter plate. Single butt straps, when treble-riveted, should be 1¼ times the thickness of plates which they connect.

11. Double Butt Straps.

Double butt straps should not be used for water-tight work, owing to difficulty in calking. They may be used to advantage, however, in connections requiring great strength but not water-tightness. The thickness of each strap should be one-half the thickness of plates connected for double riveted straps, and five-eighths the thickness for treble riveted straps. The spacing of rivets in rows should be calculated. For double butt straps the size of rivet to be used should be as follows:

For plates from 15 to 20 pounds, exclusive, ⅝-inch rivets.
For plates from 20 to 25 pounds, inclusive, ¾-inch rivets.
For plates above 25 pounds, as per Table 1.

12. Distance Between Rows.

Centers of rivets should be placed not less than 1⅝ times the diameter from the edges of plates connected. In double and treble riveting, for laps and single straps, the distance from center to center of rows, should not be less than 2½ diameters; in butt laps and double butt straps the distance between centers of rows should not be less than three diameters (butt laps should be at least double riveted). For zigzag riveting the distance between centers of rows should not be less than 1¾ diameters for rivets spaced four diameters apart in rows.

13. Length of Rivets.

Special care will be taken in riveting that rivets used are of sufficient length to insure a proper point, the aim being to have the rivet a trifle long, if possible. Such cutting as is necessary should be done while the rivet is still a dull red, and the point finished after further cooling. Allowances for length over the thicknesses connected are given in Table 3 below, the allowance being for two thicknesses only. An additional allowance of 1/16 should be added to that given for each additional thickness connected, unless the additional thickness is less than 3/16-inch, when 1/32-inch additional allowance should be sufficient. The alowances given in the table are based upon the employment of hand riveting, and are not sufficient in the case of power riveting, for which an added allowance—about ⅛-inch—should be made in each case. This table must be used judiciously and not absolutely depended upon.

TABLE 3.—ALLOWANCE IN LENGTH OF RIVETS FOR POINTS.

Diameter of Rivet. Inches	¼	⅜	½	⅝	¾	⅞	1	1¼	1½
	Allowance for point, over two thicknesses connected. Inches.								
Type of Point;									
Countersunk	5/16	3/8	½	⅝	¾	⅞	1	1¼	1½
Hammered	¼	7/16	½	⅝	¾	⅞	1	1¼	1½
Button	..	..	½	⅝	¾	⅞	1	1¼	1½

The allowances given above apply only to rivets which fit the holes neatly, as hereinbefore described.

TABLE 4. REDUCTION OF DIAMETERS TO INCHES.

Diameter of Rivet.	Number of Diameters.																	
	1 5/8	2 1/2	3	3 1/4	3 1/2	4	4 1/2	5	5 3/4	6	6 1/4	6 1/2	7	8	8 1/4	9 1/4	11 1/2	12 1/2	16 1/2	18 1/2
	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.
1/4 inch.....	3/8	5/8	3/4	13/16	7/8	1	1 1/8	1 1/4	1 7/16	1 1/2	1 9/16	1 5/8	1 3/4	2	2 1/16	2 5/16	2 7/8	3 1/16	4 1/8	4 5/8
5/16 inch.....	1/2	3/4	13/16	1	1 1/16	1 1/4	1 3/8	1 5/16	1 13/16	1 7/8	1 15/16	2	2 1/16	2 1/2	2 5/8	2 15/16	3 9/16	3 7/8	5 1/8	5 3/4
3/8 inch.....	5/8	15/16	1 1/8	1 3/16	1 5/16	1 1/2	1 11/16	1 7/8	2 1/16	2 1/8	2 1/4	2 5/16	2 7/16	3	3 1/16	3 5/16	4 1/16	4 5/16	6 3/16	6 15/16
7/16 inch.....	11/16	1 1/16	1 3/16	1 7/16	1 1/2	2	2 1/16	2 1/2	2 5/8	2 3/4	2 7/8	3 1/16	3 1/2	3 5/8	4 1/8	5	5 7/16	7 1/8	8 1/16	
1/2 inch.....	13/16	1 1/4	1 1/2	1 5/8	1 3/4	2	2 1/4	2 1/2	2 7/8	3	3 1/16	3 1/4	3 1/2	4	4 1/16	4 5/8	5 3/4	6 1/4	8 1/4	9 1/4
5/8 inch.....	1	1 1/16	1 7/8	2	2 1/16	2 1/2	2 13/16	3 1/16	3 5/8	3 3/4	3 15/16	4 1/16	4 3/8	5	5 1/16	5 13/16	7 3/16	7 13/16	10 5/16	11 9/16
3/4 inch.....	1 1/16	1 7/8	2 1/4	2 7/16	2 5/8	3	3 3/8	3 3/4	4 1/8	4 1/2	4 3/4	4 7/8	5 1/4	6	6 3/16	6 15/16	8 5/8	9 3/8	12 3/8	13 7/8
7/8 inch.....	1 7/16	2 3/16	2 5/8	2 13/16	3 1/16	3 1/2	3 15/16	4 3/8	5	5 1/4	5 1/2	5 3/4	6 1/8	7	7 3/16	8 1/8	10 1/16	10 15/16	14 7/16	16 3/16
1 inch.....	1 5/8	2 1/2	3	3 1/4	3 1/2	4	4 1/2	5	5 3/4	6	6 1/4	6 1/2	7	8	8 1/4	9 1/4	11 1/2	12 1/2	16 1/2	18 1/2
1 1/8 inches....	1 13/16	2 13/16	3 3/8	3 5/8	3 15/16	4 1/2	5 1/16	5 5/8	6 7/16	6 3/4	7	7 5/16	7 7/8	9	9 1/4	10 3/8	12 15/16	14 1/16	18 9/16	20 13/16
1 1/4 inches....	2	3 1/8	3 3/4	4 1/16	4 3/8	5	5 5/8	6 1/4	7 1/16	7 1/2	7 13/16	8 1/8	8 3/4	10	10 1/8	11 5/16	14 3/8	15 5/8	20 5/8	23 1/8

TABLE 5. BUREAU OF CONSTRUCTION AND REPAIRS, U. S. NAVY. WIDTH OF BUTT LAPS AND BUTT STRAPS. SPACING OF RIVETS.

Class of Work.....		Diametral Pitch	Ordinary Ship.									Torpedo Boat.					
Weight of Plates. Lbs.....			Up to 3 ex.	3 in. to 6 ex.*	6 in. to 8 ex.	8 in. to 13 ex.	13 in. to 20 ex.	20 in. to 30 ex.	30 in. to 40 ex.	40 in. to 51 ex.	51 and above.	Up to 3 ex.	3 in. to 6 ex.	6 in. to 7½ ex.	7½ in. to 9 ex.	9 in. to 11 ex.	11 in. to 13 ex.
Diameter of Rivets. Inches.			1/4	5/16	3/8	7/16	1/2	9/16	5/8	11/16	3/4	1/4	5/16	3/8	7/16	1/2	5/8
Diameter of Rivet Hole. "			9/32	11/32	13/32	15/32	17/32	19/32	21/32	23/32	25/32	9/32	11/32	13/32	15/32	17/32	21/32
Widths of Spacing of Rivets in inches.	Butt Laps.																
	Single riveted.....	3 1/4	1 13/16	1 15/16	1 15/16	2	2 7/16	—	—	—	—	1 13/16	1	1 3/16	1 7/16	1 5/16	2
	Double "	6 1/4	1 15/16	2 1/16	3 1/16	3 1/8	4 3/4	5 1/2	6 1/4	7	7 13/16	1 15/16	1 13/16	2 5/16	2 3/4	3 1/16	3 13/16
	Treble "	8 1/4	2 1/16	3 1/16	4 1/16	5 3/16	6 3/16	7 1/16	8 1/4	9 1/4	10 5/16	2 1/16	2 5/16	3 1/16	3 5/8	4 1/16	5 1/16
	Treble " Shell Plating....	9 1/4	2 1/16	3 1/16	4 5/16	5 13/16	6 15/16	8 1/16	9 1/4	10 5/8	11 9/16	2 1/16	2 5/16	3 1/16	4 1/16	4 5/8	5 13/16
	Butt Straps.																
	Single riveted.....	6 1/2	1 5/8	2 7/16	3 1/4	4 1/8	4 7/8	5 3/4	6 1/2	7 5/16	8 1/8	1 5/8	2	2 7/16	2 7/8	3 1/4	4 1/8
	Double " { Single Straps..	11 1/2	2 7/8	4 1/16	5 3/4	7 1/16	8 5/8	10 1/16	11 1/2	12 15/16	14 3/8	2 7/8	3 1/16	4 1/16	5	5 3/4	7 1/16
	" { Double " ..	12 1/2	3 1/16	4 1/16	6 1/4	7 15/16	9 3/8	10 15/16	12 1/2	14 1/16	15 5/8	3 1/16	3 7/16	4 1/16	5 1/16	6 1/4	7 13/16
	Treble " { Single Straps..	16 1/2	4 1/16	6 3/16	8 1/4	10 5/16	12 3/8	14 1/16	16 1/2	18 9/16	20 5/8	4 1/16	5 1/16	6 3/16	6 15/16	8 1/4	10 5/16
	" { Double " ..	18 1/2	4 5/8	6 15/16	9 1/4	11 9/16	13 7/8	16 3/16	18 1/2	20 13/16	23 1/8	4 5/8	5 3/4	6 15/16	8 1/16	9 1/4	11 9/16
	Seam Laps.																
	Single riveted.....	3 1/4	1 13/16	1 15/16	1 15/16	2	2 7/16	—	—	—	—	1 13/16	1	1 3/16	1 7/16	1 5/16	2
	Double " { a) Zigzag.....	5	1 1/4	1 7/16	2 1/2	3 1/16	3 3/4	4 3/8	5	—	—	1 1/4	1 1/16	1 7/16	2 1/16	2 1/2	3 1/16
	" { Chain.....	5 3/4	1 7/16	2 1/16	2 7/8	3 7/8	4 7/16	5	5 3/4	—	—	1 7/16	1 13/16	2 1/8	2 3/8	2 7/8	3 7/16
	Edge Strips.																
	Single riveted.....	6 1/2	1 5/8	2 7/16	3 1/4	4 1/8	4 7/8	5 3/4	6 1/2	7 5/16	8 1/8	1 5/8	2	2 7/16	2 7/8	3 1/4	4 1/16
	Double "	11 1/2	2 7/8	4 1/16	5 3/4	7 1/16	8 5/8	10 1/16	11 1/2	12 15/16	14 3/8	2 7/8	3 1/16	4 1/16	5	5 3/4	7 1/16
	Treble "	16 1/2	4 1/16	6 3/16	8 1/4	10 5/16	12 3/8	14 1/16	16 1/2	18 9/16	20 5/8	4 1/16	5 1/16	6 3/16	7 1/16	8 1/4	10 5/16
	1. Center of rivet from edge of plate.....		1 5/16	1 7/16	1 5/8	1 13/16	1	1 1/16	1 3/16	1 5/16	1 13/16	2	1 7/16	1 1/2	1 5/8	1 13/16	1
	2. Center to center of rows.																
	a) Zigzag riveting for rivets spaced 4 dias. apart.....		1 3/4	1 7/8	1 5/8	1 7/8	1 1/16	1 1/16	1 1/2	1 3/4	2	2 1/16	1 7/8	1 9/16	1 5/8	1 3/4	1 7/8
	b) Laps and single straps, double and treble riveted.....		2 1/2	2 5/8	1 13/16	1 1/4	1 1/8	1 7/8	2 1/16	2 1/4	2 1/8	3 1/16	2 5/8	2 3/4	1 13/16	1 1/16	1 1/4
	c) Butt laps and double butt straps.....		3	3 1/4	1 1/16	1 1/2	1 7/8	2 1/4	2 5/8	3	3 3/16	3 3/4	3 1/4	1 13/16	1 1/2	1 5/8	1 1/2
	3. Single riveted seams and butts..		3 1/2	2 7/8	1 15/16	1 3/4	2 1/16	2 5/8	3 1/16	3 1/2	3 13/16	4 3/8	2 7/8	1 15/16	1 15/16	1 1/2	1 3/4
	4. Double riveted butt laps and butt straps; treble riveted butt straps with alternate rivets in third row omitted.....		4	1	1 1/2	2	2 1/2	3	3 1/2	4	4 1/2	5	1	1 1/4	1 1/2	1 3/4	2
	5. Treble riveted butt laps; longitudinal seams of plating required to be watertight (excepting single riveted seams, as per No. 3); watertight floor staple work.....		4 1/2	1 1/16	1 13/16	2 1/16	2 13/16	3 3/8	3 15/16	4 1/2	5 1/16	5 5/8	1 1/16	1 3/16	1 13/16	2	2 1/4
	6. Inner bottom plating to floors and longitudinals; watertight frames and longitudinals to all plating and watertight work in general; stiffeners and other angles on bulkhead, forming support to turrets, barbettes and connection of armor-shelf angles to plating, etc.....		5	1 1/4	1 7/16	2 1/2	3 1/16	3 7/16	4 3/8	5	5 5/8	6 1/4	1 1/4	1 5/16	1 7/16	2 1/16	2 1/4	3 1/16
	7. Bulkhead stiffeners at or below the waterline; angles of boiler and engine foundations and foundations in general.....		6	1 1/2	2 1/16	3	3 7/16	4 1/2	5 1/4	6	6 3/16	7 1/2	1 5/16	1 7/16	2 1/16	2 5/8	3	3 3/4
	8. Clips and angles of floor plates, brackets, lightened intercostals, etc.; keelson angles beyond limits of double bottom, if not watertight.....		7	1 3/16	2 5/16	3 1/2	4 3/16	5 1/16	6 1/8	7	7 7/16	8 3/4	1 3/16	2 1/16	2 5/16	3 1/16	3 1/2	4 3/16
	9. Non-watertight frames and longitudinals to shell plating; deck plating to beams; bulkhead stiffeners above water line and in general where special strength is not required..		8	2	3	4	5	6	7	8	9	10	2	2 1/2	3	3 1/2	4	5

a) and Zigzag Riveting in general. — Chain Riveting in all cases unless otherwise specified. * in. = inclusive; ex. = exclusive.

TABLE 6.—RIVETING OF ANGLES.

Flange Size.....Inches.....	1	1¼	1½	1¾	2	2¼	2½	2¾	3	3½	4	4½
Diameter of Rivet..... "	¼	5/16	3/8	7/16	½	9/16	5/8	11/16	¾	7/8	1	1⅛
Center of Rivet from Heel of Bar..... "	9/16	11/16	13/16	15/16	1⅛	1¼	1⅜	1½	1¾	2	2¼	2½

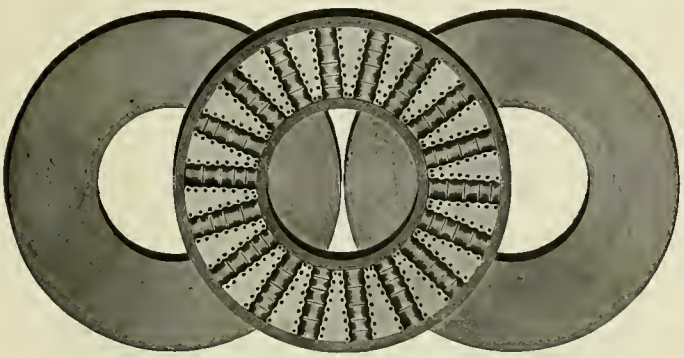
ENGINEERING SPECIALTIES.

The Contraflo Condenser.

This condenser, which was illustrated and described at some length in our September number, is manufactured by Messrs. Richardson, Westgarth & Company, Limited, Hartlepool Engine Works, Hartlepool, England. In principle, the direction of flow of the steam is opposed to that of the cooling water, which fact accounts for the name: contra-flow.

A Roller Bearing for Thrust Purposes.

Often there is need for a thrust bearing to eliminate friction upon shafting, cranes, turn tables, etc., where the space is too small to permit the use of a ball bearing, and for this purpose the Bantam Anti-Friction Company, Bantam, Conn., has produced a thrust roller bearing consisting of cylindrical rollers held together in a bronze or steel cage, as shown in the illustration,



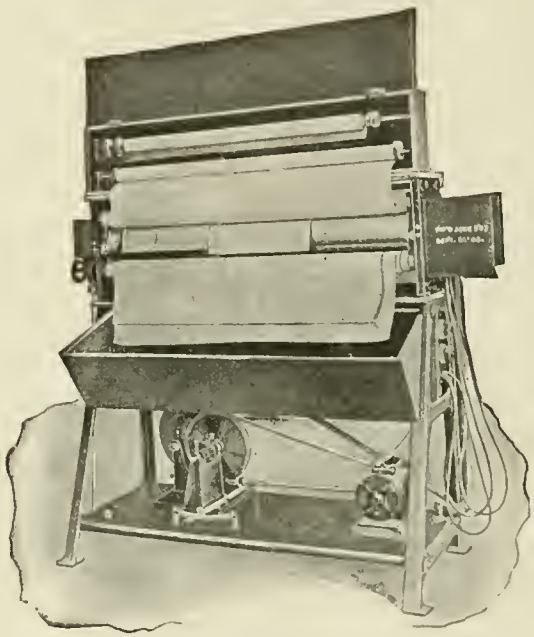
supported on either surface by hardened and carefully ground steel collars. The length of each roller is about one-half its diameter, which reduces to a minimum the slipping and sliding of the roller when revolving around the center of the shaft. For slow speeds these bearings give excellent satisfaction.

It is plain to every mechanic and engineer that the tendency of these rollers is to travel always at a tangent to the motion of the retaining case. At any high speed their action would be that of a milling cutter cutting endwise, and they would also slip and slide instead of rolling, but for slow speeds they give excellent results, and will carry enormous loads as compared with the ball bearing. They will eliminate about one-half of the friction found where such devices are not used.

The Everett-McAdam Blue Print Machine.

The machine consists of a rotating glass cylinder which lies in a series of narrow belts, and within which cylinder are placed two mercury vapor electric lamps. The roll of paper to be printed is placed in a box on top of the machine and feeds in continuously between the belts and the cylinders; or if only a few prints are wanted, previously cut sheets of paper may be fed in. The tracings are inserted between the paper and the cylinder, and, after passing around three-fourths of the circumference of the cylinder, are deposited with the paper in a box in the front part of the machine, the printing being done from the inside of the cylinder as the paper and tracings travel around it.

It is possible to make prints five feet wide and of any length whatever, and the device is particularly adapted to making numbers of small prints on one long sheet of paper, or on previously cut sheets—which come out in a regular stream—and of an absolutely uniform tone. One great feature of this continuous machine is that it suffices to handle one tracing at a time, the small ones being fed in side by side, while the paper feeds in automatically from a continuous roll. The tracings go in and come out on the same side of the machine, so that the leading edge of a tracing may be started into the machine again before the trailing edge comes out, saving considerable time where more than one print is wanted from one tracing. This was very nicely illustrated by



making twelve prints from one six-foot tracing on a single sheet of paper seventy-two feet long, without wasting an inch of paper or a second of time between prints.

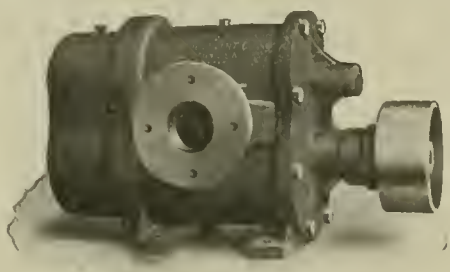
The lamps used are particularly adapted to this kind of work, as they give out only chemical rays—no energy being lost in non-chemical light, and as the printing is done from the inside of the cylinder, the light strikes the paper at right angles and the machine has an absolutely maximum electrical efficiency. The machine is very compact, requiring a space only two feet by five feet and is entirely self-contained. It is driven by a motor, and the speed can be instantly changed to any rate desired by moving a convenient lever. The machine has been placed on the market by the Revolute Machine Company, 523 West 45th street, New York.

High Pressure Blowers.

These are designed for handling air or gas at any pressure below ten pounds per square inch. They may be used to advantage in supplying air blast for foundry cupolas, forge fires, smelting furnaces, hardening, tempering, and annealing furnaces, whether supplied with coal, gas or oil; for pneumatic tube systems; for moving granular material; and in fact for furnishing air or gas for any purpose where the maximum pressure does not exceed the limit of ten pounds.

The blower, which is of the so-called positive type, is manufactured in a variety of sizes and capacities ranging from five cubic feet to over 15,000 cubic feet per minute. It consists of four principal parts; the cast iron shell or casing, two rotating members,

or rotors, and a stationary core. The rotors are held in position by bearings mounted on the end plates, and are made to revolve at the same speed, being connected by gears. As one of the rotors, called the impeller, revolves, it forms pockets or chambers in the annular space between the core and the shell, which imprison the air and carry it from the suction to the discharge, its return being prevented by the other rotor. Each pocket, as it nears the discharge, is decreased in volume, and consequently delivers its air at greater density.

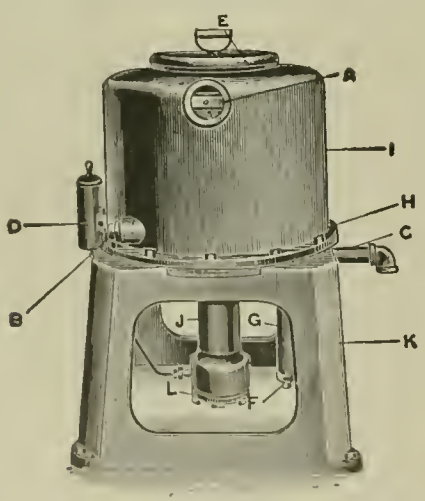


The other rotor, called the idler because it does no work, simply acts as a valve to allow the impeller blades to return to the suction side of the machine without loss of compressed air. All the work of compressing and moving the air is done by the impeller, which is mounted on the driving shaft, and no power is transmitted through the gears to the idler except that which is necessary to overcome the friction of the journals. Because all the work is done by one shaft, the load on the engine or motor is constant, the gears are relieved of all but a small fraction of their usual duty, and the wear is correspondingly reduced.

These blowers are built by the B. F. Sturtevant Company, Hyde Park, Mass.

Oil and Waste Saving Machines.

There has been installed on some of the battleships of the United States navy a machine for cleaning the filter cartridges used about the engine rooms, the cartridges being put into the machine and the oil or grease extracted. The machine is manufactured by the Oil & Waste Saving Machine Co., Philadelphia. It consists of a shell and a steam turbine driven basket. There

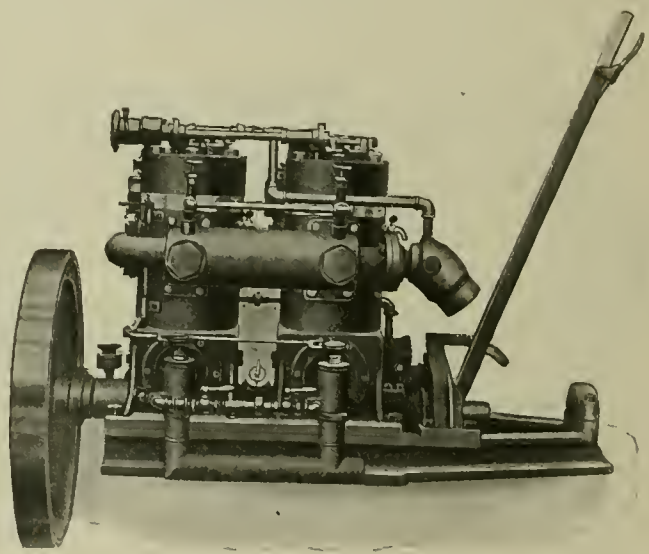


being no belts, shafts or other driving gearing, it readily appeals to the marine engineer. The material containing the oil or grease is put into the basket and the steam turned on. The steam passing through the jet strikes the turbine, revolving the basket, and then passes up through the material and exhausts at the top. The heat from the exhaust steam, acting on the oil or grease, loosens it and thus allows almost perfect extraction by centrifugal force. It takes from five to thirty minutes to a charge. In this time ninety-eight percent of the oil or grease is extracted from the waste or other material containing it. There being no foreign material used to aid extraction, the oil or grease and waste or other material are in condition to be used over and over again. The machine requires little space and can be set on the floor or hung to a wall or staging.

A Convertible Kerosene Motor.

We show herewith a convertible gasoline or kerosene motor which is being placed on the market by the Fay & Bowen Engine Co., Geneva, N. Y. This company has manufactured this motor for a number of months, during which time it has been thoroughly tested and perfected, the best evidence of its success being that their foreign agents, to whom the first machines of this type were shipped last season, are ordering them for this season in larger quantities.

The machine is a complete gasoline motor, and can be operated on gasoline. When used for kerosene the fuel is applied through needle valves above the exhaust pipe on the port side. The kerosene is placed under a slight pressure in its tank, not more than ten pounds pressure being required, and the operation and regulation of the machine under its kerosene fuel is said to be perfect. The charge is not ignited by the hot tube, which is the usual method in kerosene engines, but it is ignited by an electric spark, thus giving a vastly greater range of speed control than is usual in a kerosene motor.



When operated on kerosene exclusively the motor is started by removing two hexagonal plugs in the exhaust pipe, and applying heat from a torch for three to five minutes, when the machine will start readily. After being started and warmed up, it will stand for some time if necessary to stop it, and will start again without further heating. If it is not desirable to use a torch, the machine can be started by priming the cylinders with gasoline from a squirt-can, through the priming cocks on the cylinder heads, and after priming two or three times the machine is sufficiently warmed to operate on the kerosene fuel. It can also be started by the use of gasoline in the regular way through its gasoline vaporizers, and after starting, the gasoline can be shut off and the kerosene turned on, when the motor will operate entirely on its kerosene fuel. These different methods of starting give the operator a wide range, and make the machine practical for either the pleasure launch or the heavy service boat.

In this machine the vaporization of the kerosene fuel is very thorough and the unpleasant odor from the exhaust, which has heretofore been a disagreeable feature of all kerosene machines, is largely eliminated. The manufacturers of this motor have also conducted a series of experiments with alcohol, and the machine is found to operate successfully on that fuel, applied and handled in the same manner as kerosene. The motor is being made in single or multi-cylinder types, from 3½ horsepower upwards.

TECHNICAL PUBLICATIONS.

Parsons Turbine Engineer's Log. Size, 11 by 13 ¼ inches. Pages, 32. Glasgow, 1906. James Brown & Son.

This consists of a log for sixteen days, giving all the particulars required by the engineer through the six watches of the day, and covering the various items included in the engineer's log for a transatlantic or other liner. The thing is worked out in considerable detail, and spaces are given for various kinds of fuel, oil and engine stores, as well as for temperatures, weather observations, power indications by torsion meter, revolutions, steam pressures, etc. The book should be very handy for all engineers operating turbine machinery, because everything necessary to be recorded day by day appears to be provided for in the tables.

The Theory of the Steam Turbine. By Alexander Jude. Size, 6¼ by 8¾ inches. Pages, 296; illustrations, 252 + three folding plates. Philadelphia, 1906. The J. B. Lippincott Company. Price, $5.00 net.

In this volume an attempt is made to present the fundamental principles of the operation of a steam turbine in a concise and connected manner, and in a way which will enable these principles to be applied directly to the turbine problem. The descriptive matter included has been curtailed to a minimum, but is in sufficient quantity to afford an idea of present developments and probable future progress in design and manufacture. Treatment is given of the subjects of leakage, governing, etc., and the results of some hitherto unpublished researches on the impact of steam into the buckets and flow through them, and the erosion of metallic surfaces due to the impact of high velocity steam. Several side issues have been brought into the book in the shape of applied thermometry, and the subject of the specific heat of superheated steam, these being of particular importance in connection with steam turbine work.

The illustrations are almost entirely in the nature of line cuts, showing sections of various parts of the apparatus; diagrams showing the operation of steam, both in itself and in connection with nozzles and buckets; diagrams showing the relation between various features connected with the operation of the turbine, such as steam pressure, vacuum, consumption and power, and the expansion of steam. The efficiency of turbines is taken up in considerable detail, including the influence of the relative lengths and thicknesses of the vanes, and the effect of leakage. The text appears to be thoroughly well illustrated by the numerous cuts, and to cover the ground with considerable thoroughness. All of the principal commercial types of turbines are represented, and detailed descriptions given of each.

Elements of Gas Engine Design. By Sanford A. Moss, M. S., Ph. D. Size, 3¾ by 6 inches. Pages, 197. New York, 1906. D. Van Nostrand Company. Price, 50 cents.

This work is an attempt to present in condensed form all of the fundamental principles connected with the design of gas engines, giving a complete exposition of simply those elements which are of direct interest to the designer. No attempt was made to go into mathematical or constructional details. Most of the work treats of the Otto-cycle engine operating on the well-known four-stroke principle, and each discussion applies primarily to the single-acting trunk piston engine using this cycle. In some places, however, the discussion applies equally well to other cases. The subject is divided into fourteen chapters, of which the first five relate to the chemistry and physics of gas engines, and to various sorts of fuels used in their operation. The next chapter takes up the discussion of cylinder action, as affected by changes in exhaust and admission. Five chapters are devoted to compression, combustion, expansion, speed, power and efficiency, and methods of governing. The remainder of the work is concerned with cylinder action in two-cycle engines, details of design, and formulas and constants used by the designer. Four tables are given covering various subjects connected with the design and operation of the gas engine.

The Motor Boat and its Machinery Outfit. By Bruno Mueller. Size, 4¾ by 7¼ inches. Pages, 183.; illustrations, 126. Hanover, Germany, 1906. Dr. Max Jaenecke. Price, in paper covers, 2.40 marks; bound in cloth, 2.75 marks.

This little book is the sixth volume of a technical series being issued by the publisher, and is intended to bring before the reader in the most condensed manner possible the present condition of the motor boat industry in the line of design and operation. The illustrations consist of both line drawings and half tones, and cover in considerable detail both the boat and machinery.

The subject of the propeller comes up for attention, and turbine propellers, as well as reversible propellers, are given considerable space. The gearing for reversing the direction of operation of the propellers is also described, as well as the operation of propellers in tunnels extending above the water line. The engine is described in detail, not only the conventional types of motor boat engines being given, but also Diesel motors and producer gas outfits. Electric motors come up for brief consideration, and motor generator outfits are also described. The subject of the design and construction of the boat is given considerable attention, and is illustrated by both line drawings and half tones. The drawings cover both general arrangement plans and, in a few cases, the lines of the hull.

Boring and Turning Tapers. By Fred H. Colvin. Size, 5½ by 8 inches. Pages, 25; figures, 22. New York, 1906. The Derry-Collard Company. Price, in paper covers, 25 cents.

This is the second edition of No. 1 of the series of practical papers now being issued by the publishers, and is practical in every respect, showing the methods of turning tapers by means of offsetting the working centers of the lathe, as well as the operation of taper turning attachments with lathe centers in proper alinement. The subject of boring, and of cutting threads along taper lines, is given similar treatment, the whole outline of the work being of such a nature as to appeal directly to the man performing the various operations.

Transactions of the Institution of Naval Architects. Volume XLVIII, 1906. Edited by R. W. Dana, M. A., Secretary of the Institution. Size, 8½ by 11 inches. Pages, 228; folding plates, 40. London, 1906. Henry Sotheran & Company.

The scope of this work is well known, and all that is necessary in giving an outline of its character is to list the papers included and illustrated in its pages. These are:

The new Scouts of the British Navy.

Vessels Constructed for Service in Colonies and Protectorates.

Yacht Racing Measurement Rules and the International Conference.

The Subject of Motor Boats and Their Rating for Racing Purposes.

The Design and Construction of High Speed Motor Boats.

Gas Engines for Ship Propulsion.

The Efficiency of Surface Condensers.

Notes on the Freeboard Rules.

The Overhead Wire Cableway Applied to Shipbuilding.

The Introduction of Cranes in Shipyards.

Oil Tight Work in Ships of Light Construction.

Steam Yachts: Some Comparisons.

The work also includes lists of members, and minutes of the various business and professional meetings. It goes without saying that the illustrations are of exceptional scope and interest, and include a very large number of cuts, scattered over the forty plates. These are mostly in the nature of line drawings, but a few half tones are given of the various vessels described.

Bureau Veritas; thirty-seventh year; General List of Merchant Shipping. Two volumes: steamers, size, 10 by 7¼ inches; pages, 1,685. Sailing vessels, size, 7¼ by 9¾ inches; pages 1,213. 1906. Paris, 8 Place de la Bourse; and London, 155 Fenchurch street, E. C. Price of the complete work, £3 3 s; steamers, £1 15s. Sailing vessels, £1 10s.

This work requires no introduction, it being the regular list of all merchant vessels of the various maritime powers, with the

usual particulars in the way of dimensions, powering, ownership, builders, etc. The books include also illustrations of the various types of vessels, together with tables showing the total tonnage and number of vessels of the various powers, as well as alphabetical lists of owners of fleets of vessels, with the respective tonnages. In addition to this, tables are given showing all the vessels under the several flags arranged in order of signal letters. At the end of the volume of Steamers is given a table showing all the dry-docks, patent slips, floating dry-docks and marine railways in all the ports of the world.

American Stationary Engineering. By W. E. Crane. Size, 5½ by 7¾ inches. Pages, 285; figures, 107. New York, 1906. The Derry-Collard Company. Price, $2.00.

The preface states that this book is intended to be a plain book of every day work about engines, boilers and their accessories. It makes no pretensions to scientific or mathematical treatment, all formulas used being placed in a simple form covered by a knowledge of arithmetic. No detailed description is given of such items as are treated in considerable detail in special books, these items being such as the indicator, slide valves, etc., but the work is expected to cover pretty thoroughly answers to all questions which are liable to come up in every day operation of a steam power plant. The illustrations are carefully drawn, and serve to explain the text in such a way as to make everything simple reading. At the end of the work will be found a considerable list of questions which would be likely to be asked at an examination for a license to operate steam machinery, and a number of tables have been collected from various sources, giving the principal characteristics of saturated steam, together with areas and circumferences of circles and areas of segments of a circle. The whole idea of the work is practical rather than theoretical, much of it being drawn from the personal experience of the author.

Internal Energy; A Method Proposed for the Calculation of Energy Stored Within Matter. By John V. V. Booraem, M. E. Size, 6 by 9¼ inches. Pages, 144; figures, 35. New York, 1906. McGraw Publishing Company. Price, $1.00.

The purpose of this work is to suggest a simple working hypothesis whereby the amount of chemical energy stored within a body may be estimated. It is based upon various lines of experimental data, the idea having originated several years ago from a mathematical study of the periodic curves of the atomic volumes and melting points. Through a combination of the methods of algebra and analytical geometry an attempt was made to discover why these curves were not solvable from the values of their ordinates. It was ascertained that to accomplish this purpose the determination of several constants was necessary, and also that as chemical energy was measured by heat, it was possible that chemical change could be measured by expansion through heat. On this basis the work was started, and includes considerations of expansion, as a measure of physical change. This is subdivided into general subjects of Cohesion versus Heat; the Individual Struggle between Atoms where Heat Measures Cohesion; the Energy of Atomic Pressure; Development of Chemical Energy; Units of Mass, Measure and Expansion; Chemical Volumes; Study of Stress and Volume by Groups; the Calory; Calculation of Latent Heat of Vaporization; the Origin of a Perfect Gas; the Melting Point; Specific Heat of Solutions; Latent Heat of Fusion; Methods of Calculating Energy of Cohesion; Liquidity.

SELECTED MARINE PATENTS.

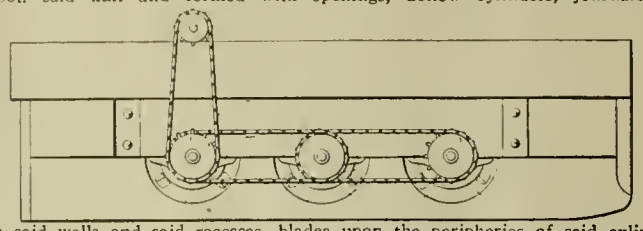
The publication in this column of a patent specification does not necessarily imply editorial commendation.

829,472. LIFE-SAVING DEVICE. OTTO HESSEL, BALTIMORE, MD.

Claim—1. A life-saving device comprising a frame raft, a series of air-tight compartments within the frame, of horizontal metal rods within the inner open frame parts, of a net slidably secured on the rods, of rope handles provided with cork floats secured and suspended from the exterior upper sides of the frame parts. Three claims.

829,658. BOAT. LUTHER J. BUTTERFIELD, MILWAUKEE, WIS., ASSIGNOR TO JAMES A. ALEXANDER, MILWAUKEE, WIS.

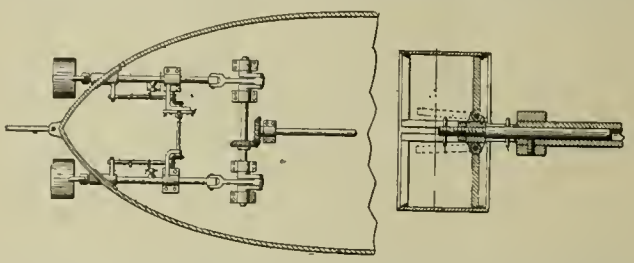
Claim.—3. A boat comprising a straight body or hull having tapered ends and a longitudinal series of wells, a keel upon said hull having recesses formed therein to aline with said wells, an overhanging deck upon said hull and formed with openings, hollow cylinders, journaled



in said wells and said recesses, blades upon the peripheries of said cylinders, a drive-shaft mounted upon said deck, rotary elements upon said shaft and shafts of said cylinders, and driving connections between said rotary elements. Three claims.

829,681. BOAT-PROPELLER. FRANK C. TAMBLING AND HARLAND CHARLES, EAGLE RIVER, WIS., ASSIGNORS OF ONE-THIRD TO CHARLES A. RUSCO, CHICAGO.

Claim.—1. In combination with a boat-hull, a tubular propeller-casing outside the hull; means by which it is mounted and reciprocated longitudinally on the hull; a gate-carrier mounted for longitudinal movement in



the propeller-casing; a gate hinged thereto adapted to swing wholly within the casing from position at which it obstructs the passage therethrough either way to unobstructing position, the propeller-casing having two longitudinally separated stops, and means for moving the gate-carrier to carry the gate at obstructing positions to one or the other stop at will. Three claims.

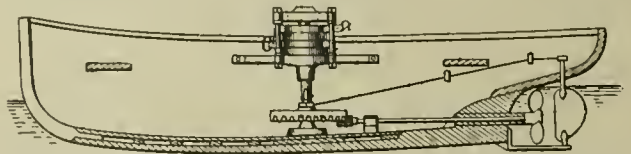
829,747. PROPELLER. ROBERT A. WORKMAN, PHILADELPHIA, PA., ASSIGNOR, BY DIRECT AND MESNE ASSIGNMENTS, TO LUTHER D. LOVEKIN, PHILADELPHIA.

Claim.—6. The combination with the hull of a vessel of a tubular extension from the same, a substantially conical shell having its base adjacent

to the rear of said extension, a propeller and a shaft in the extension supporting said propeller between the end of said extension and the shell, there being a normally closed opening through the base of the shell adjacent to the shaft. Six claims.

829,782. BOAT. TIMOTHY HANLEY, BOSTON, MASS.

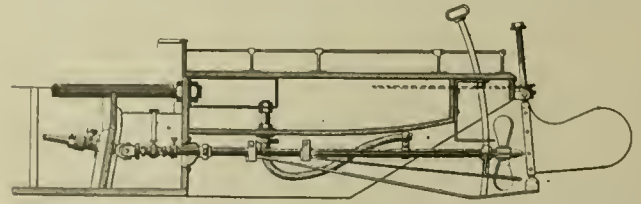
Claim.—1. The combination with a boat having a propeller-shaft, of a power-shaft geared thereto, duplicate driving mechanism arranged for co-operation with the power-shaft, and manually-operated means connected



with each of said driving mechanisms, said operating means extending in opposite directions from the driving mechanisms to permit operation of the propeller-shaft from either or both ends of the boat, and rudder-operating means revolubly supported by the power-shaft. Three claims.

830,908. MARINE VESSEL. JOHN W. MARTIN, SCOTTSBURG, IND.

Claim.— 3. A marine vessel having a propeller-shaft, a universal joint connecting said shaft with the driving-shaft, a tubular shaft encircling the



propeller-shaft, a propeller in connection with the propeller-shaft, side and bottom guard-rods, connected with the tubular shaft, a rudder-post having a rudder and connected with the bottom guard-rod, and means connected with the tubular shaft for vertically swinging the propeller shaft. Four claims.

UNIVERSITY OF TORONTO
LIBRARY

Do not
remove
the card
from this
Pocket.

Acme Library Card Pocket
Under Pat. "Ref. Index File."
Made by LIBRARY BUREAU

Author Vol. 11, 1906
Title Marine Engineering
DATE
6672